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ABSTRACT

To study the effect of variations in amount of material between response frames in programed instruction on the learner's performance on several criterion tasks, four programs in different subject areas were prepared. Each had four versions differing only in frequency of response frames. The resultant 16 programs were presented to 180 tenth grade students who were randomly assigned to four treatment groups, each of which worked through four programs representing all four subject areas and all four versions. Criterion measures were four-week delayed achievement tests in each subject, completion time records, error score records, and attitude scales. Significant differences were found among the treatment groups on completion time only; mental ability and reading scores were found to be strong predictors of success. The results of the study suggest that curriculum material developers should consider abandonment of high response frequency programed instruction and seek a better approximation to the laboratory operant model. (Author/SP)

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Nova University

Fort Lauderdale, Florida 33314

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U. S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

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SUMMARY

The purpose of the project described in this report is to study the effect of variations in unit size (i.e., amount of material between response frames) in programmed instruction on the learner's performance on several criterion tasks. Several discrepancies appear to exist between linearly programmed materials and the laboratory operant conditioning paradigms after which programmed instruction is patterned. The focal point of these discrepancies centers on the reinforcement aspects of programmed instruction and include the problems of lack of research in shaping meaningful verbal material and the questionable reinforcing qualities of feedback in programmed instruction.

To investigate these concerns, the frequency of responding was varied in programmed materials and the effects were studied. The research was exploratory and the objectives were to answer the following questions:

(i) If the unit size in linearly programed instructional material is varied while all other material-centered variables are held constant, will there be a differential efficiency of learning regardless of the individuals involved?

(ii) Does the optimal unit size, if any, vary with the content of the program?

(iii) Does the optimal unit size, if any, vary with the specific individual learner?

(iv) Can learner-centered variables be identified which will enable accurate predictions of success to be made with respect to frame size and content?

Four commercial programs were edited and modified to be similar in format and structure. These covered the subject areas of astronomy, computer programming, psychology, and statistics. The programs were all prepared with 896 frames. Each was prepared in four versions which differed only in the frequency (density) of response frames (response frames were eliminated by filling in the blanks with the correct response).

The Versions are:

(1) Every frame is a response frame.
(2) Every fourth frame is a response frame.
(3) Every 16th frame is a response frame.
(4) Every 32nd frame is a response frame.

The resultant 16 programs (four contents X four versions) were used in a Greco-Latin square design with tenth-grade high school students. Initially 196 students were sampled, but only 180 of these were actually enrolled in school. Since students could be excused from the study at their parents' request, attrition became a major problem and while some data were collected on all 180, only 45 finished all aspects of the study.

The students were randomly assigned to four treatment groups and each treatment group worked through four programs representing all four subject areas and all four versions. Criterion measures were four-week delayed achievement tests in each subject, completion time records error score records, and attitude scales. Additionally, data were collected on various learner-centered variables including age, sex, mental ability, reading ability (3 scores), cognitive style, interest in each subject, and background in each subject.

Because of the attrition problem, a discriminant function analysis was used to compare the four resultant treatment groups on the learner-centered variables. No significant differences were found either in the multivariate case or any of the univariate cases. Thus, it was concluded that the randomness of the treatment groups was maintained.

Discriminant function analyses were run among the treatment groups for each of four classes of criterion variables. No significant differences were found for the achievement test scores among the groups. This supports the possibility that programmed instruction is discrepant from its operant model. As would be expected, significant differences were found among the treatment groups on completion time with the materials requiring more responses generally requiring more time to complete.

Because of the difference in the maximum possible number of errors across versions, error scores were converted to the proportion of possible errors. No significant differences were found among the groups for these converted error scores. Similarly, the groups were not found to differ on attitude scale scores.

The third question asked above as an objective proved to be unanswerable within the scope of the study. However, it was established that strong trends for individual variations across unit sizes did not exist where such variations were monotonic and summable.

Multiple linear regression was used for the fourth question and remarkably strong predictions were obtained. R^2's ranged from .65 for the computer programming achievement test to .81 for the astronomy achievement test. In two cases, the obtained R^2's slightly exceeded the maximum R^2's permitted by the test reliability and in a third case, the R^2 was almost as high as the maximum. Strongest single predictors were mental ability and the reading scores.

Recommendations are made to curriculum material developers to consider abandonment of high response frequency programmed instruction and to seek a better approximation to the operant model. Suggested future research includes replication of the study under various conditions including additional criterion measures. Also, future research should study individuals to determine if unit size variations make a difference to some people even though the pooled effects show no differences.

Chapter I

PROBLEM AND RELATED RESEARCH

Problem Statement

A major trend in American education today is individualized instruction in which an attempt is made to match the curriculum to the needs and characteristics of each student. While various models of individualized instruction are being suggested and employed (e.g., IPI, PLAN, PRIME), there is very little known about how to match specific modes and media to individuals and where to begin instruction on a specific subject with a particular child. Thus, matching instruction to students is still largely an unresolved problem in education.

One of the reasons why educators do not have guidelines for matching instruction to the child is because all of the relevant variables have not been identified and because many of those which are identified are only poorly understood. Another reason is that the more basic question of how tailor-made a curriculum must be to permit optimum growth in each student has not been resolved. Some educators and psychologists tend to believe that a single curriculum can be devised to serve for everyone. For example, many programmed instruction and contingency management advocates believe that the proper application of reinforcement is the crucial point in curriculum and that other curriculum concerns can be minimized or ignored. The polar position is that individual differences are great enough to require a wide variety of learning experiences to meet the needs of various people and that in the extreme each individual should have a different curriculum. The resolution of these positions is largely an empirical question subject to extensive research. However, it is unlikely that a single experiment or even a series of experiments can answer the questions since the problems are quite diffuse and the possible curriculum-learner combinations are infinite. Single studies can shed light on very limited aspects of the problem and can be expected to leave more unanswered questions than answered ones.

In the present study, programmed instruction (PI) has been studied in an attempt to identify the relationships or lack of relationships between various learner characteristics and certain material variables. Programmed instruction frequently has been used as one method of individualizing instruction, but there are no guidelines as to where or how it can best be employed. Skinner (1958) advanced his version of PI as an optimum instructional device for learners in general, but the evidence to date does not substantiate its general superiority over other methods. The research on PI tends to give a variety of results on its usefulness and there has been little consistency of findings (e.g., see reviews by Silberman, 1962 and Schramm, 1964). Hence, while Stolurow (1963) has recommended that autoinstructional and conventional methods be alternated in the classroom, there are no rules or guides for the implementation of autoinstruction unless it is believed superior to all other instruction.

In addition to its role as a potential individualizing agent, PI merits study because it permits a greater control over variables in the learning situation than do other, more conventional, methods of instruction. This characteristic permits some study of the more basic learning phenomena to be undertaken in field research. There are, of course, a great number of variables operative in any learning situation and Fry (1963) has identified 212 variables in PI. Obviously no one study can hope to meanfully manipulate more than a few of these variables. Elsewhere, the salient independent variables involved in auto-instruction have been grouped into five categories (Flynn, 1968). These categories are

(1) structural or format variables;

(2) content variables;

(3) learner-centered variables;

(4) structure-learner interaction variables; and

(5) content-learner interaction variables.

While some overlap may exist among these categories, the structural and content variables are material centered and are independent of the learner. Similarly, the learner-centered variables are independent of the structure and content. The two interaction categories are dependent upon the learner and upon the materials and involve such characteristics as the learner's prior experiences with the particular content and structure.

In the present investigation, variables in four of these categories were either manipulated or measured and the fifth category was partially taken into account. The variables studied are listed below by category:

(1) Structural: Amount of material presented between response elicitations (i.e., unit size) was varied.

(2) Content: Programs in four subject areas were used.

(3) Learner-centered: Variables including sex, age, reading ability, intelligence, and cognitive style were measured.

(4) Structure-learner interaction: No variables were varied or measured, but all Ss were given a brief familiarization period with each type of structure.

(5) Content-learner interaction: Measures were taken of Ss interest in each content area and of Ss prior experience with each content area.

The structural variable of unit size is defined as the amount of material presented between elicitations of responses. In one sense unit size is a "size of step" problem, but since size of step has been used in at least five different ways, its use will be avoided in referring to the present study. A "unit" as used in the present study can contain one or more frames. A unit is terminated by the presence of a response frame (i.e., one eliciting a response) and all other frames in the unit, if any, are non-response frames. If a unit consists of a single frame, then that frame must be a response frame. A frame is operationally defined in the present study as a discrete amount of material containing one or more sentences and being physically separate from other such amounts of material.

One reason why unit size was selected for stuy is because there has been only little evidence supporting the position advocated by Skinner (1958) that programs comprised of very short frames provide optimum learning for all individuals and consequently various investigators disagree with this position. For example, Deterline (1967) states that steps which are too small "can actually interfere with the desired learning" (p. 212). Similarly, Pressey, who is considered the father of teaching machines, states that "detailed small-step programming may be exceedingly useful--but surely not for everybody on everything" (1960), p. 503).

Part of the problem with short frame programs may be caused by several apparent descrepancies between reinforcement theory and the mechanics of auto-instruction. First, auto-instruction does not seem to fit the operant paradigm as characterized in laboratory studies. Since the stimuli and responses both vary throughout a program, the student basically must learn the content in PI in a single trial. If this is true, the response of a small frame may only be related to the content of that frame as has been suggested by Deterline (1967).

Secondly, since responses in PI are elicited by specific cues, PI differs from operant studies in which the responses are emitted rather than elicited. Because of this, Lumsdaine (1962) has suggested that PI may better fit contiguity theory than reinforcement theory.

A third problem in relating PI to reinforcement theory has been suggested by Scandura (1966) who points out that shaping techniques have not yet been specified for meaningful verbal material. Consequently, the learning principles discovered in laboratory studies involving the modification of overt behavior may not be directly useful in teaching symbolic material.

If these problems did not exist and if PI does adequately parellel the operant paradigm, a further consideration is that feedback (i.e., knowledge of correctness of the response) may not be reinforcing. Reinforcement is defined to occur when the behavior preceding the reinforcing event has en increased probability of occurence and a basic tenet of PI is that feedback is such an event. However, if the learner's response is not correct, seeing the correct response is not analogous to a laboratory situation in which an animal fails to emit the correct response. In PI, the learner is provided with information by which he can covertly correct his error. In the typical laboratory experiment, the animal is given no information after an incorrect response except that the experimenter or the apparatus fails to respond.

On the other hand, seeing the correct response does not necessarily provide the learner with a reinforcing event. Briggs, et al. (1962) report a study in which students who read frames without overtly responding had superior test scores and time-efficiency over those who overtly responded. These frames were ones of low difficulty based on the degree of cueing, and the investigators point out that in this case the overt responses with the resultant feedback were not as effective as no responses. In related findings, Licklider (1962) reports that highly motivated students found scores and comments unimportant in a computer-assisted instruction study, while the unmotivated students relied upon them. These studies tend to indicate that feedback in PI cannot be categorically classified as reinforcing, but that rather, its reinforcing qualities depend upon the learner in relation to the program. A testimony to the relative lack of reinforcement in PI are several recent studies which have used contingency management as additional motivation in PI tasks (e.g., Homme, 1964 and Clements and McKee, 1968).

If these descrepancies do exist between PI and other manifestations of operant conditioning, then the effect of having frequent responses in PI cannot be predicted from reinforcement theory. This is especially true if feedback is not consistantly reinforcing.

One approach to studying the effect of responding is to eliminate the responses while holding all other variables constant. Silberman (1962) summarized 15 studies on the relative effectiveness of overtly responding versus covertly responding in PI. Two of the studies found overt responding produced higher test scores, four found that covert responding produced higher scores, and the remaining nine showed no difference. Briggs et al. (1962) report a study in which one group of students worked through linear programs which required overt responding while another group worked through the same programs with the response blanks filled in. The reading group surpassed the overt responding group in the efficiency of time and in achievement test scores for the frames which were heavily cued. This suggests that frames which provide easy prompts for the student are not as effective a teaching device as reading the same material.

Krumboltz and Kiesler (1965) studied the effects of varying the frequency of asking questions and of providing feedback on those questions in PI. They used six versions of a 177 frame program. These versions, presumably arranged in descending order of the amount of reinforcement they provide, are:

1. The standard program in which a question was asked on every frame with the answers provided.

2. A question on every frame with the answer provided for every fifth frame.

3. A question on every frame with the answer provided for every tenth frame.

4. A question only on every fifth frame with answers provided.

5. A question only every tenth frame with the answers provided.

6. No questions asked with all frames consisting of declarative statements.

Achievement test results of the high school students in the sample differed significantly in an analysis of variance with scores decreasing from version 1 through 6, except for version 5. Delayed test results (2 months) showed no significant differences.

There is some indication that the data in the study did not have homogeneous variances (see Flynn, 1968) which could produce significance where it does not exist. Assuming, however, that the findings are valid, the study generally supports the position that frequent responding facilitates learning in PI. However, it also suggests that reinforcement is present with or without knowledge of the correct answers.

In another study, Flynn (1968) found that the frequency of responding made no difference with tenth and eleventh grade students on a criterion test. Seven versions of a 864 frame psychology program ranging from responses on every frame to no responses at all were used with seven treatment groups. While competition times varied significantly across groups, scores on an achievement test did not. This suggests that in this case responding and its feedback were not important to learning (or that reinforcement was present with or without responding).

Thus, the research to date has not provided a definite answer to the effect of responding in PI. If its effects cannot be predicted by reinforcement theory, then the divergent results reported above are to be expected. The present study has further explored the effects of response frequency.

In addition to the structural variable of unit size, the content of the programs were varied in the present study. Primarily, this was done to determine if the effects of the other variables--such as unit size--were content specific or not. Thus, programs in astronomy, computer programming, psychology, and statistics were employed. These particular subject areas exhibit some variation in the relation of verbal to numeric content and in the degree of abstractness.

It is difficult, if not impossible, to vary the content of PI without also varying other variables. For example, the type of content often dictates the type of illustrative materials employed. Further, different content will contain technical words and jargon in varying frequencies and the type of such terms will be qualitatively different. In the present study in which commerical programs were employed as the source of the instructional materials, differences will occur in the original length of the frames, in the readability of the materials, and in the degree to which the material is programmed. The latter variable has been identified by Holland (1967) and is the extent to which the required response is dependent upon the other content in the frame. Thus, variations in the content will tend to introduce extraneous sources of variation that will confound comparisons across the content areas. Although some adjustments for these differences were made in the present study, in general differences in criterion variables across the content areas must be attributed to all the differences among the programs and not just to content.

Various learner-centered variables were also studied. One reason for including these variables was to determine if the effectiveness of the PI materials varied as a function of the learner characteristics. Secondly, if the effectiveness does vary, the learner characteristics can perhaps provide some prediction of that effectiveness.

While various learner-centered variables have been studied in relation to criterion measures on PI, there is lack of agreement on the importance of individual differences in PI. Skinner-type programs have been assumed to level out individual differences, while branching programs capitalize on them. The empirical data has also been undecisive in resolving the problem, with some investigators finding individual differences to be important in PI while others find that they are not.

The effects of intelligence have been extensively studied in relation to PI achievement. Tuel (1966) summarizes some of the research in this area and reports that the findings are "somewhat equivocal." Kapel (1965) found no relationships between intelligence and PI achievement. Shay (1961) found a relationship between intelligence and error rate but not with achievement. Melching (1965) found relationships between several measures of intelligence and achievement in PI. Flynn (1968) found a significant correlation between achievement test scores and ability. Alter (1963) and Tuel (1966) report a relationship between intelligence and retention over time in PI. Snelbecker and Downes (1967) report that PI reduces but does not eliminate individual differences in ability and personality. Stolurow (1961) reviews some of the literature on the relation between ability and performance on PI and concludes that at that time there was no reason to assume that the same program could not be used with students at different levels of intelligence. He cited two studies which indicated an interaction exists between ability and reward. While these studies were not with PI, the existence of such an interaction could explain some of the inconsistency of findings on the effect of ability.

Various other learner characteristics have been studied in relation to performance on PI. Several of these studies are cited here as examples of what has been done. Kapel (1965) studied the effects of reading comprehension and found relationships with achievement. Kight and Sassenrath (1966) found anxiety was related to criterion measures on PI, but Lache (1967) and Ripple et al. (1965) failed to find significant relationships with anxiety. McNeil (1964) found sex to be related to achievement, but Filep (1967) found sex was an unimportant variable. Feldhusen and Eigen (1963) found a relationship between attitudes and achievement in PI.

In brief, the evidence is confusing regarding the effect of individual differences on PI. However, there is a long history of finding individual differences to be important in various endeavors and it would be quite surprising if they were not important in PI.

At least part of the divergent findings in PI studies is probably accounted for by poor controls in much of the research. Studies frequently involve very short programs, lack of control over acquisition experiences, data which fails to meet the assumptions of the analysis techniques employed, inadequate criterion measures, biased sampling, and generally poor designs. For example, a review of one study (Flynn, 1967) identified 11 principle deficiences in the research. Silberman in 1962 stated that research on PI was quite limited and that "beyond demonstrating that a carefully written set of materials will teach if the student will spend enough time on them, we have little unequivocal evidence for the principles of programmed instruction." The situation has not improved much since then.

No structure-learner interaction variables were experimentally manipulated or measured in the present study, but the students were given brief familiarization periods with each program prior to working on the material on which the criterion measures were based. While some of the students had had prior experience with PI they would not be expected to have had experience with the different unit sizes manipulated in this study.

The content-learner interaction was taken into consideration by measures of the students' interest in the particular subject area and by measure of their previous experiences with them. In general, PI does not make allowances for students' previous knowledge of content; instead all students must begin at the same point and are requested to overtly respond even though they may be quite familiar with the content. While in general, repeated learning or even overlearning is not considered detrimental, compelling the student to respond could impede the learning process if PI does parallel animal operant studies. If behavior shaping is involved, the knowledgeable student must have existing behavior reshaped. The analogous laboratory situation is not repeated trials on a task, but is the reshaping of the animals behavior. For example, having a pigeon which was trained to turn circles relearn to turn circles would parallel the PI situation. This procedure would not only be a waste of time but would undoubtedly interfere with previously learned behavior.

In summary, the problem under consideration in this study is the determination of the effect on learning criterion variables of different unit sizes in PI. Since learning in general is at least in part a function of learner characteristics, various learner variables were measured and their relationships to the criterion variables were studied.

Objectives

The purpose of the study is to explore a delimited aspect of the general problem of identifying optimal learning materials for given individuals. The specific question being asked is the following:

Is there an optimal unit size (i.e., frequency of response elicitations) for learning to occur in linearly sequenced auto-instructional programs and if there is, is this unit size related to the program content and/or to certain learner-centered variables?

Following from this question, the objectives of the study are to determine answers to the following questions:

(i) If the unit size in linearly programed instructional material is varied while all other material-centered variables are held constant, will there be a differential efficiency of learning regardless of the individuals involved?

(ii) Does the optimal unit size, if any, vary with the content of the program?

(iii) Does the optimal unit size, if any, vary with the specific individual learner?

(iv) Can learner-centered variables be identified which will enable accurate predictions of success to be made with respect to frame size and content?

The study is exploratory, and no specific hypothesis are being tested.

Chapter II

PROCEDURES

Sample

A sample of 196 students was selected from the tenth grade at Nova High School in Fort Lauderdale, Florida to participate in the study. Nova High School is an experimental school which draws students from throughout Broward County, but most of the students are from middle class homes. This school was selected in particular because the flexible scheduling permitted students to be scheduled into special classes for the study.

In the initial planning of the study, it was decided to use two groups of 80 students each with the second group being a complete replication of the study. However, in order to compensate for expected attrition, the administration of the high school was asked to schedule 200 students into classes for the project. The tenth grade was selected because the administration stated that the schedules of tenth graders were most likely to permit the addition of the project as a class. No specific selection criteria were employed. The schools' computer scheduling program was instructed to attempt to schedule all tenth graders into one of eight sections entitled "Nova R" (Nova Research). Of about 500 tenth-grade students, approximately 400 were scheduled into Nova R. Since this was twice the number of Ss required, four sections were arbitrarily dropped. The four sections remaining each had 49 students for a total N of 196. However, 16 of these students were not actually enrolled in school, so that only 180 students were in the sample. Two sections were used in the first trimester of the 1968-69 school year and two sections were used in the second trimester.

Since Nova R was an extra class which the students took in addition to their regular courses, the high school administration required that students be given the option of not participating in the study. While such a procedure creates methodological problems it was adhered to and a letter describing the project was prepared and distributed to the students at the first session of the class. At the bottom of the letter was a permission slip to be signed by the parents giving or denying the student permission to participate. A copy of this letter is included in Appendix A.

Attrition became a serious problem in the study since many students were excused at their parents' request and only a total of 45 students completed all parts of the study (although some data were collected on most of the students). The resultant characteristics of the sample and the causes and effects of the attrition are discussed in Chapter IV.

Materials

Four commercially prepared auto-instructional programs were selected for use in the study. These programs are Introduction to FORTRAN, (Plumb, 1964), Analysis of Behavior, (Holland and Skinner, 1961), Programmed Astronomy I - The Solar System, (Sullivan and Sullivan, 1963), and Descriptive Statistics - Volume I - A Programmed Text (Gotkin and Goldstein, 1964).[1] Permission was obtained from each of the publishers to modify and reproduce materials as required by the study.

The criteria used in selecting the specific programs were (1) that the contents be ones in which the students would probably not be knowledgeable; (2) that the length of the material be long enough to provide several hours of instruction; and (3) that the programs be representative of the principles of the Skinnerian approach (i.e., small frames with overt, structured responses, and linear sequencing). The last criterion was included because only programs of this type can be readily adapted to the needs of the study. For example,if the programs were branching, it would be extremely difficult to combine frames to vary the unit size. Also branching programs generally have longer frames and usually require multiple-choice responses rather than constructed ones.

The different subject fields represented by the materials provide for variation in the skills required by the students and are different enough to appeal to different interests. Further, the programs can be loosely listed on a continuum reflecting their numeric content with statistics being most numeric, followed by FORTRAN, astronomy, and psychology in order.

Frames were selected from each of the commercial programs and after editing, eight hundred ninty-six frames in each content area were used for the study. In general, the frames used were taken in sequence starting at the beginning of each program. Some editing was done to make the programs approximately parallel in construction in terms of the length of frames and form of responses. Some of the original frames in the commercial programs required the student to select a multiple-choice answer. These frames were rewritten to require a structured response by the student. Several original frames required multiple responses and these were rewritten to require only a single response.

The programs were edited so that the number of words in each frame was at least 5 and no more than 40. Most frequently, this was accomplished by combining two or more smaller frames and by spliting larger frames so the length criteria were met. Even after this editing, differences in frame length existed between the four programs. Table 2-1 gives the mean frame lengths in number of words and number of sentences based upon a sample of 40 frames from each program.

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[1] Brief descriptions of the content of each of the programs are contained in Appendix B.

Table 2-1

Mean Frame Length in Number of Words
and Sentences Based on 40 Frames

	Programs			
	Astronomy	Computer Programming	Psychology	Statistics
Mean # of Words	23.5	27.1	24.6	19.2
Mean # of Sentences	1.42	1.25	1.45	1.28

The four programs also can be expected to vary in other characteristics. For example, the readability of the programs can be expected to vary since there is some variation in the age levels for which each of the original programs was prepared. Since there seems to be no measure of readability especially designed for use with programmed materials, the Dale-Chall formula for regular prose was used (Dale and Chall, 1948a and 1948b). Five selections were sampled from each program and the readability was determined. The formula revealed differences among the programs as shown in Table 2-2. Thus, the astronomy and statistics programs should be easier to read than the other two.

Table 2-2

Readability of the Four Programs Based
on the Dale-Chall Formula

	Programs			
	Astronomy	Computer Programming	Psychology	Statistics
Mean Raw Score	6.95	8.17	8.33	6.83
Corrected Grade Level	7-8	11-12	11-12	7-8

In addition to frame length and readability, the programs probably vary from each other in various other ways. For example, the degree to which they are programmed according to Holland's definition (1967) and as discussed in Chapter I probably varies. Likewise, the amount of redundancy and cueing can be expected to vary. However, it would be extremely difficult to have programs vary in content and not in any other characteristics. Consequently, as mentioned earlier in this report, differences in student performance among the four programs cannot be attributed solely to content, but are a function of all of the differences which exist.

The first ninty-six of the frames in each program were used as introductory material to familiarize the students with the particular version and content and were not used as a base for collecting data. The remaining 800 frames were used for the study and provided the instructional situation from which data were collected. The introductory materials were presented in booklets separate from the other materials. The two booklets were designated Part I and Part II respectively for each subject area. In addition to frames, both Part I and Part II booklets contain several "Exhibits" (i.e., graphs, tables, pictures, explanatory materials, etc.). Originally only the psychology program contained exhibits per se, and the illustrative material in the other programs had to be grouped to form the exhibits.

Each of the four programs were rewritten into four versions with all variables except unit size per response held constant. These versions are:

(1) Small frames as originally written.

(2) Material of four of the smaller frames combined.

(3) Material of 16 of the smaller frames combined.

(4) Material of 32 of the smaller frames combined.

For illustration, the following are four adjacent original frames from the psychology program.

> In withdrawing the hand from the hot surface, arm movement is a response which is elicited by a painful ___ to the hand.
>
> In the hand-withdrawal reflex, the stimulus must be intense enough to exceed the ___ or no response will occur.
>
> A light flashed into the eye elicits constriction of the pupil. This sequence is called the pupillary ___.
>
> In the pupillary reflex, a flash of light is said to ___ the response.

These four frames are used verbatim in Version 1 of the psychology program, but for Version 2 they were modified as follows:

> In withdrawing the hand from the hot surface, arm movement is a response which is elicited by a painful stimulus to the hand.
>
> In the hand-withdrawal reflex, the stimulus must be intense enough to exceed the threshold or no response will occur.
>
> A light flashed into the eye elicits constriction of the pupil. This sequence is called the pupillary reflex.
>
> In the pupillary reflex, a flash of light is said to ___ the response.

The only change for Version 2 is that the responses have been filled in for the first three original frames. Consequently, only one response is now required for the four frames combined. The original spacing and format is maintained so that the only change is the unit size or frequency of responding. In the subsequent versions, responses only occur for the last original frame in each of the composite frames.[2]

The particular versions used were selected to maximize differences in the criterion variables based on the findings of a previous study (Flynn, 1968). The previous study used the same basic psychology program (but with 64 additional frames) as the present study with seven different versions of unit size. These versions were:

(1) Small frames as originally written used as units.

(2) Material of two of the smaller frames combined as an unit.

(3) Material of four of the smaller frames combined as an unit.

(4) Material of eight of the smaller frames combined as an unit.

(5) Material of 16 of the smaller frames combined as an unit.

(6) Material of 32 of the smaller frames combined as an unit.

(7) Material of all of the smaller frames combined so that no responding is required.

The last version (Version 7) was eliminated from the present study because it may be qualitatively different from the other versions since responding is not required. Figure 2-1 graphically summarizes the findings by version on the earlier study (see discussion in Chapter I).

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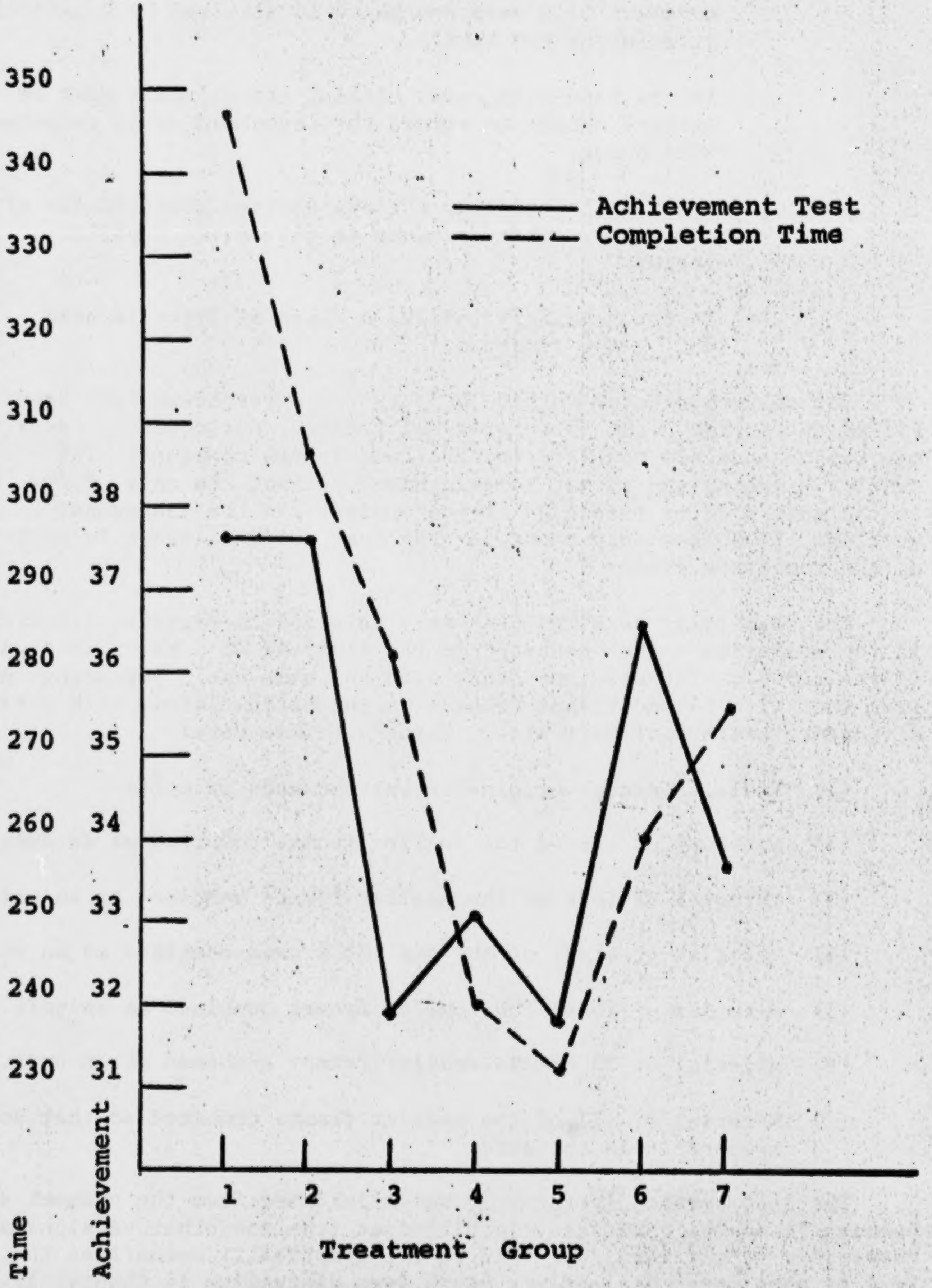
[2] Examples of each of the four versions of the psychology program are contained in Appendix B.

Figure 2-1

Mean Performance of Treatment Groups on Achievement and Completion Time in a Previous Study[a]



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[a] Flynn (1968)

No overall significance was found among the achievement test scores, but the completion times did differ significantly. From these findings, the following decisions were made:

(1) Version 1 (original frames) was selected because

   a) it is the basic unit and is most comparable in format to the commercial programs.

   b) the Version 1 treatment group had the highest achievement test mean.

   c) the Version 1 treatment group had the highest completion time mean and differs significantly from all other groups except the Version 2 group.

(2) Version 3 (four frames combined) was selected because the Version 3 group

   a) represents a low on achievement test means.

(3) Version 5 (16 frames combined) was selected because the Version 5 group

   a) represents a low on achievement test means.

   b) represents the lowest completion time.

(4) Version 6 (32 frames combined) was selected because the Version 6 group

   a) represents the highest point on the right hand side of the U shaped completion time curve (after Version 7 was eliminated).

   b) represents the highest achievement test score on the right hand side of the U shaped curve.

While, these findings were obtained with only the psychology program, they are the only relevant empirical guidelines available. Consequently, they were used as the basis for selecting the experimental versions of material in all four content areas.

Design

Since various learner characteristics could affect the students' performance on the different unit sizes, a repeated measures design was employed in which all students worked with each unit size. Using repeated measures minimizes the need to assure comparability among the treatment groups on various variables (the sample is small enough that random assignment to groups would probably not ensure the uniform distribution of the relevant characteristics).

Since the students could not work through the same materials repeatedly, different contents were used with each student for each unit size. To allow for possible ordering effects of the unit sizes and the contents, a Greco-Latin square design was employed as illustrated in Figure 2-2.

Figure 2-2

Greco-Latin Square Design Employed

		Treatment Group			
		1	2	3	4
Time	1	aα	bβ	cγ	dδ
Periods	2	bγ	aδ	dα	cβ
	3	cδ	dγ	aβ	bα
	4	dβ	cα	bδ	aγ

KEY:

α - Astronomy

β - Computer Programming

γ - Psychology

δ - Statistics

a - Version 1

b - Version 2

c - Version 3

d - Version 4

Initially, it was planned to use the square shown in the figure with 80 students in the first trimester and to use a second, orthogonal square with the second group of 80 students in the second trimester. However, the high attrition rate in both trimesters made that unfeasible and a single Greco-Latin square was used with the subjects in both trimesters (see Chapter IV for a discussion of the attrition).

If the order of the presentation of materials is a significant factor in the students' achievement, then the use of a single Greco-Latin square might give biased results. The use of the second square would have better permitted the detection of an ordering effect. The most likely expection is that the sequence per se is not particularly important, but that the students' attitudes and their degree of motivation might have changed as they progressed through the study. If such changes did consistently occur, then the students' performances on the criterion measures should reveal them. For example, if the students became increasingly bored as they progressed, then their performance on each successive program should decline in each of the treatment groups. This problem is more thoroughly examined in the chapter on the analysis.

All four sections of Nova R meet for the first two classes in the first trimester while the project was explained and some initial data were collected (see below). On the second day, two sections were arbitrarily dismissed until the second trimester and the high school gave these students free time during the first trimester.

After the initial dropout from the sample was completed (i.e., those students whose parents initially requested they not participate and those students who were not actually enrolled in school) the remainder of the students in the two sections in the first trimester were randomly assigned to one of four treatment groups corresponding to the columns in Figure 2-2. In the second trimester, the students who remained after the initial dropout were randomly assigned to the same four treatments so as to even out the groups.

The first few days of the classes were used to explain the project and to collect initial data (see next section) on the students according to the following schedule:

Class 1: Pass out and explain parental letters.
Have students complete information sheets.

Class 2: Dismiss two sections and have remaining students complete subject background questionnaires, High School Curriculum Survey, and Pick Two Pictures Test.

Class 3: Administer Henmon-Nelson Test.

Class 4: Administer Nelson-Denny Test ✓

Class 5: Begin Students on materials.

Students who were absent on any of the data collection days were requested to complete the instruments which they missed at a later time.

Monitors were employed to supervise the classroom and to distribute the materials and tests to the students throughout the trimester. The students worked independently without monitor assistance. The classes at Nova High School meet on an every other day basis, so the Nova R sessions alternate between a two-day week (Tuesdays and Thursdays) and a three-day week (Mondays, Wednesdays, and Fridays). There were 37 class days in the first trimester and 33 in the second.

External contingencies were not provided to motivate the students' performances and although the students were promised a grade for their participation, the grade could not become a part of their high school record. When students finished the study, they were excused from Nova R and were given free time.

Learner-Centered Variables

Data on a number of independent variables were collected on the students. The variables on which these data were collected are listed below together with the instruments employed and the rationale for collecting them. The Information Sheet which is listed refers to a brief questionnaire the students completed on the first day of the class. The construction of the instruments which were developed especially for this project is described in Chapter III and copies of these are included in Appendix C.

1. Sex. Each student recorded his or her sex on the Information Sheet. That sex differences influence learning has frequently been documented in various situations. In programmed instruction, for example, McNeil (1964) found that kindergarten boys surpassed girls in PI on reading, but Filep (1967) found that sex was not an important variable with junior high school students on an auto-instruction task.

2. Chronological Age. Each student recorded his month and year of birth on the Information Sheet. Since all of the students were in the tenth grade, age is fairly homogeneous within the sample. However, within the narrow range of age in the sample, the relationship of age to the criterion measures is examined.

3. Number of Years at Nova. The number of years previously in attendance at Nova High School was recorded by the students on the Information Sheet. This information was collected to determine if prior experiences in an individualized curriculum are related to the criterion measures. However, this is not considered to be an important variable.

4. Courses in which Currently Enrolled. The students listed the courses in which they were currently enrolled on the Information Sheet. Thus, information about the curriculum track the students were following was available and its relationship to the criterion measures was explored. Further, students who were currently enrolled in courses similar to the subjects covered by the PI materials could be identified.

5. Reading Comprehension and Vocabulary. Because PI is primarily a verbal task, the students' reading ability can be expected to play an important role in achievement. For example, Kapel (1965) found a relationship between reading comprehension and achievement in programmed learning.

   The Nelson-Denny Reading Test published by Houghton-Mifflin was used to measure reading comprehension, vocabulary, and reading rate. Alternate form reliability for comprehension is .81 and for the other scores it ranges between .92 and .93. The test has received good reviews in Buros' Mental Measurement Yearbook. Form A was used in the study.

6. Intelligence. Mental ability by definition should bear a strong relationship to most cognitive learning tasks. While some researchers claim PI should eliminate intelligence differences, others have not found this to be the case. Shay (1961), Alter (1963), and Tuel (1965) are among the investigators who have reported finding relationships between intelligence and achievement to PI.

   The instrument employed was the Henmon-Nelson Tests of Mental Ability (Revised Edition) which is a paper-and-pencil test published by Houghton-Mifflin. The publishers report an odd-even reliability of .95 and .94 for forms A and B respectively and an alternate form reliability of .89. This test also has received good reviews in Buros. Form A was used in the study. The raw score was used in the study rather than an IQ score because the interest was in mental ability independent of chronological age.

7. Interest in Subject. An interest inventory was developed to determine the student's relative interest in the four subject (content) areas used in the study: Interest has been shown to be related to learning in programmed instruction in some situations, (e.g., Campbell, Bivens, and Terry, 1963). In addition, it is an everyday observation that a person who is interested in a subject will pursue it more vigorously than a person who is not interested.

   The instrument is entitled High School Curriculum Survey and its development is described in Chapter III. Four scores are given by the instrument showing the relative interest held by the student in each of the four content areas of the programs.

8. Cognitive Style. Cognitive style refers to an individual's preferences in organizing and categorizing his perceptions and concepts of his environment. Some people are found who tend to look at the details in situations while others tend to look at the wholes. Since programmed instruction is an analytic approach to learning, the cognitive style of an individual should have some influence on how he achieves in this medium. This is especially true in the present study since the unit size variable influences the degree to which the materials are analytic.

   The instrument which was used is the Pick Two Pictures form developed by Kagan, Moss, and Siegel (1963). This instrument consists of a series of 19 groups of three pictures each. The student is instructed "to pick out two of the pictures that are alike in some way," in each group and to "write your reason for picking these two pictures." There are no correct answers, and usually any two of the three pictures may be selected on some logical basis. However, if pictures are selected because of similar detail, the student is considered to be analytic in his choice; if they are selected because of non-analytic characteristics, the student is considered to be global in his choice (Kagan and his associates identify three conceptual categories and here "Inferential-categorical" and "Relational" have been combined as non-analytic).

The usual practice in scoring the instrument has been to conclude that the person is analytic in his thinking if a majority of items were chosen on an analytic basis, and to conclude that he is non-analytic if the reverse situation prevails. The scoring was modified in the present study by using the actual number of analytic choices as continuous score, rather than using a dichotomy.

9. Prior Knowledge of Subject. What a student knows about a particular subject when he begins a new course has an effect upon his performance in the course. If he knows most of the materials that will be covered, he can probably get through the course with a minimum of effort. If the course is structured for maximum growth and if the student is motivated, a student who knows a great deal about a particular course can greatly advance his knowledge beyond that of a naive student. If a student knows only a little or nothing at all about a course, he will probably have to expend more effort than the student who is more knowledgeable, and he is not likely to advance as far as the student who has prior knowledge. Further, as discussed in Chapter I, a particular problem may exist in PI with knowledgeable students if behavior shaping is involved as has been theorized by some.

While it is important to know how much the students know about the content prior to the study, measurement of knowledge in a particular area prior to a course in that area may establish expectations for the students about what is important in the course. While this phenomena creates no problem in the normal classroom situation--infact it would probably improve the learning process--it does create a problem in research which attempts to evaluate the effectiveness of a given method of instruction. If gain scores per se are not a concern in the study, direct measurement of existing knowledge through a pretest can often be omitted. However, the decision not to use gain scores must be justifiable and some other method should be employed to assess the existing knowledge.

In the present study, partial control of existing knowledge in the content areas which were employed in the study has been effected through the inclusion of subject matter which is largely novel to high school curriculum. While the contents of the four programs to be employed (descriptive statistics, astronomy, psychology, and computer programming) are sometimes taught in high schools, they are usually electives which only a small number of students take. Also, they are usually taught in the last two years of high school, so that the sample of tenth graders was not likely to have had courses in any of these fields.[3] For this reason, gain scores and the direct measurement of existing knowledge can be omitted with only a minimum of error, thus avoiding the problems of pretesting.

Nevertheless, the possibility exists that some of the students did have prior experiences in one or more of the four topics, if not through formal instruction, then through informal reading, mass media, or association with people in these fields (e.g., parents). In order to take any existing knowledge into account in analysing the data of the present study, four instruments were developed which indirectly determine prior experiences within each of the content areas, without establishing students' expectations for the course. The development of the instruments is described in Chapter III. The instruments are entitled, Astronomy Questionnaire, Computer Programming Questionnaire, Psychology Questionnaire, and Statistics Questionnaire.

Two additional learner-centered variables were originally proposed for the present study. These were dogmatism as measured by the Rokeach Dogmatism Scale and school motivation as measured by the Jim Scale. However, these tests were not administered because of a stand taken by the Broward County School Board against tests of a "psychological" nature. Subsequent to the submission of the proposal for this project, the Broward County School Board adopted a strong position against psychological and attitudinal testing. Part of the testing policy adopted reads as follows: "No tests other than standard intelligence aptitude and achievement test shall be scheduled or administered without the expressed consent of the board." The policy also provides that if a test is approved, parents must be notified by mail on school board letterhead of the testing and must be given the opportunity to inspect the instrument prior to testing. Because of these restrictions the Rokeach Dogmatism Scale and the Jim Scale were submitted to the Superintendent's office for clearance. It was informally decided by that office that the tests would not receive Board approval. Consequently, these two tests were regretfully dropped from the data collection effort.

Criterion Measures

Several different criterion measures were used in the study.

These are listed below.

1. Completion Time. The classroom monitors maintained logs of the time each student had the programmed materials. While these times are regarded as completion times, they do not

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[3] Nova High School does offer an elective course in computer programming and several students in the sample had either previously taken it or were concurrently enrolled in it. This problem is discussed in the analysis section.

necessarily reflect the amount of time the student actually worked with the materials, but merely the amount of time for which he had them in his possession. Sometimes the monitors were aware that a student was not working on the materials and deducted the time from the record.

2. Achievement Test. Achievement tests were developed for each of the four subject areas covered by the programmed material. The tests are in a multiple-choice format and involve recognition recall. How the tests were constructed and their reliabilities are discussed in Chapter III. Each test was given four weeks after the student completed the corresponding program (see discussion below).

3. Response Error Rate. The number of errors made in responding to the response frames in each program was recorded by each student. Record sheets were provided on which the student wrote each solicited response. They were instructed to mark incorrect responses with a large X and these X's were later tallied by the student to indicate the total number of errors. While this method allows room for students to falsify their records, it has been used elsewhere (e.g., Flynn, 1968 and Kapel, 1965). The instructions stressed that the students would not be penalized for the number of errors made.

   Error rate indicates the difficulty of the material for the learners involved and in a programmed instruction study has little value as an ultimate criterion of effectiveness. Rather, its importance is in terms of how it relates to the other criterion measures.

4. Attitude Scales. Student attitudes were recorded using brief questionnaires containing Likert-scaled items. A single questionnaire was prepared in four versions to reflect the four content areas. The development of these questionnaires is described in Chapter III.

Two additional criterion measures were originally proposed but were not used. These were immediate tests and transfer tests. Each achievement test was to have an alternate form developed, with one form to be used to measure immediate achievement and the other for delayed retention. The decision not to develop two forms was due to the change in timing of the study. As planned, the initial phase of the study in which the instruments were prepared would have coincided with the first part of the school year and would have made available independent samples of students to pretest the instruments. As funded, however, the initial phase occurred during the summer and students were not readily available to use for instrument pre-testing. Consequently, in the absence of a pre-study sample to empirically equate the alternate forms of the achievement tests, it was decided not to develop them.

Had the alternate forms been developed, it had been planned to divide the treatment groups into at least two subgroups, and preferably four, in order to vary the presentation order of the alternate forms. (The high attrition rate would have prevented the subgrouping, anyway, had the other tests been developed).

The decision to use the achievement tests as delayed retention tests rather than as immediate tests was made for two reasons. First, the previous study with psychology materials (Flynn, 1968) showed no significant difference among the treatment groups on an immediate test. Second, the intent of curriculum materials is usually to provide for retention of content over time as opposed to immediate achievement only. Hence, the results using a delayed testing are of more practical value and interest than are results using only an immediate test.

The decision not to use the transfer tests was made for a different reason. These tests were conceived to consist of items which would require the student to apply and interpret the content of the programs to problems which were not contained in the programs themselves. This was not done because the original estimates for the time and difficulty involved in developing such tests were not realistic. After an initial attempt, it was decided that the time and labor involved would be disproportionately great compared to the duration of study and that the tests could probably not have been developed in time for use when the first students would have been ready to take them.

Chapter III

INSTRUMENT DEVELOPMENT

Several instruments were developed for use in the study. These include both criterion instruments and learner characteristic instruments. The development of these is described in this chapter and copies of the instruments are contained in Appendix C.

In the proposal for the present study, plans were outlined to pretest the various instruments on an independent sample of students. This was feasible when the proposal was submitted, because the timing was proposed to be such that instrument development could take place during the first part of the regular school year when students would be available. However, with a subsequent delay in funding, the first phase of the study did not coincide with the school year. Consequently, the pretesting of instrumentation was omitted because of the appropriate samples of students were not available. Therefore, measures of reliability and validity are not available independent of the students who were engaged in the research (except for the Psychology Achievement Test as noted below).

High School Curriculum Survey

An instrument was developed to measure the students' relative interest in each of the four content areas of astronomy, computer programming, psychology and statistics. The interest, however, is measured in terms of students' reactions to the names of courses rather than to any specific content. The interest instrument--named High School Curriculum Survey--consists of 140 pairs of course titles (randomly arranged) and the student is instructed to "select the course in each pair which you THINK you would prefer to take" (the complete instructions are in Appendix C). The instrument is scored for each of the four content areas by counting the number of times that the course title corresponding to that content area was selected as preferred. The title of each of the four content areas appears in 15 different pairs so that the maximum scores is 15 for each area.

In addition to the four areas of astronomy, computer programming, psychology, and statistics, 21 other course titles are used in the pairs. Twelve of these titles together with the four content areas of interest are combined in all possible pairs which accounts for 120 pairs. Consequently, the four content areas are included in 54 pairs including the six pairs which only involve the four. One pair of the 120 was accidently repeated (this pair did not involve any of the four content areas) which leaves 19 pairs (of 140 total) made up of the remaining 9 course titles. These 19 pairs were randomly selected and do not involve any of the four content area course titles. Consequently, a base of 120 pairs consisting of the possible combinations of 16 course titles make up the nucleus of the instrument. This nucleus, then, permits each course to have a unique rank if the student is consistent in his choices.

The course titles included as buffer items in the nucleus of 120 pairs were selected within the following general specifications:

1. Courses are included which are novel to the curriculum since the four content areas were in part selected because of their uniqueness in the curriculum.

2. Courses which are common to high school curriculums are also included to provide an adequate comparison base.

3. Courses which are included cover a variety of discipline areas and include courses which are in the same general disciplines as the four content areas.

4. An attempt was made to vary the conceptual level of the courses which are included to provide a range of comparisons.

Using the first three criteria, a list of 50 courses (including astronomy, computer programming, psychology of learning, and statistics) was compiled. The course titles used were largely taken from a list of courses offered by a high school (Criterion 2) and from several undergraduate college catalogs (Criterion 1).

For the fourth criterion, conceptual level was arbitrarily defined in terms of two dimensions. These dimensions are a verbal-numeric continuum and a concrete-abstract continuum. Other dimensions could have been employed instead which also would have provided a basis for ensuring a range in the nature of the courses included. The list of 50 course titles was given individually to five judges who were first asked to "rate each course according to the content which you think is implied by the title" on a five-point continuum from verbal to numeric. Then the same five judges were asked to rate the courses on a five-point continuum from concrete to abstract.

The ratings of the judges were used to reduce the list of course titles according to the following criteria:

1. Courses were selected when the judges' ratings were in complete consensus at any of the five-points on the scale. This provided a range on each of the two dimensions made up of titles which evoke similar concepts of content in different people in terms of either the verbal-numeric dimension or the concrete-abstract dimension.

2. Courses which had mean ratings essentially identical to each of the four content areas were selected. Courses were included in this category if their mean rating fell within 1/2 point of the mean of any of the four content areas on both continuums (without regard to variance).

3. Courses for which the ratings were distributed identically to the ratings for any of the four content areas on either continuum were selected.

Criteria 1 and 2 both provided more courses than were needed and selection of particular courses was made on other bases such as selection by both criteria 1 and 2 or by distribution across discipline. In some cases, the choice was essentially random.

The number of courses to be included was arbitrarily set at 16 in an attempt to make the instrument long enough to get some spread among the rankings but not so long that it would be extremely boring or would require an excessive amount of time to complete. The number probably could have been selected as 14 or 18 or some other similar number without an appreciable difference in results. However, n courses form n(n-1)/2 pairs so the list becomes unmanageably large very quickly.

The additional 9 course titles were included to provide some variety to the pairs--so that the student would not have to read the same 16 titles repeatedly without variation. The 19 pairs represented by these 9 course titles were randomly selected. They include only 2 pairs made up solely from the 9 titles and 17 pairs made up of one member from the 9 and one member from the twelve other course titles (excluding the four content areas).

Since complete consistency in picking the preferred member of each pair will result in unique rankings for each of the four content areas, the frequency of ties in rankings should provide an indication of how consistent the students are in their selections. A total of 103 students in the sample completed the instrument, and of these, 33 or 32.0% had tied rankings for two or more of the four content areas. There are 65,536 ways in which 4 things can be assigned ranks from 0 to 15 and 21,856 or approximately 33.3% of these involve ties.[1] Thus, if the four contents had been ranked randomly, 33.3% could have been expected to be tied. The 32.0% actually tied is not significantly different from 33.3% ($Z < 1$) which tends to indicate a lack of consistency in the ratings.

A possible explanation for the lack of consistency is that some students knew they were going to withdraw from the project and did not take the instrument seriously. If this is true, students who stayed in the program should have fewer ties than those who withdrew. Fifty-four of the students who completed one or more programs had 13 ties or 24.1% (1 student did not complete the instrument). Forty-nine students who dropped out of the program had 29 ties or 59.2%. This difference yields a χ^2 of 3.31 which is not quite significant at the .05 level. However, the difference is large enough to suggest that those students who dropped out tended to be less consistent in picking courses than those who finished one or more programs.

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[1] The total number of ways is n^4 or 16^4 and the number of ties is $n^4-n(n-1)(n-2)(n-3)$.

Of the 54 students who finished one or more programs, only 44 finished all four programs and completed the instrument. Considering these 44, only eight or 18.2% had ties in rankings. When this figure is compared against the 29 ties among the 49 students who dropped out without completing any of the programs, a χ^2 of 5.54 is obtained which is significant ($p<.05$, $df = 1$). Thus, it appears that the consistency of the instrument is related to the students' completion status. This indicates that the High School Curriculum Survey can be used as a predictor of criterion variables for students who completed the study, but should not be used to discriminate between dropouts and non-dropouts.

A test-retest reliability check was not made although such a check would give a good indication of the stability of the items over time. Further, the stability of each pair could be examined and unstable pairs could be eliminated.

The validity of the instrument must be considered in terms of content validity. It is obvious that a variety of contents could be actually offered under each of the course titles included in the instrument. Thus, a student's preference for a particular course title does not necessarily mean that he would actually like such a course were he enrolled in it. In cases of the courses which are common to high school curriculums (algebra, general physics, etc.) many students have had previous experiences with them and can pick or reject them from an experiential base. This is not true, however, in the case of the less common courses (such as aerodynamics, practical logic, etc.). Here the student must respond in terms of his mental image of such courses based at best on heresey, popular press, and vicarious experiences. This was the main reason course titles were included in the final instrument when the five judges agreed on the point at which they fell on either of the two continuums (Criterion 1)--to have course titles which evoked similar conceptions of content from different individuals.

Since some of the course titles are not regularly included in High School Curriculums, it is quite conceivable that at least some of the students did not know what the title meant and had no idea of the nature of the course content. In fact, some students asked what some of the course titles were while they were taking the instrument (they were not told the meanings since everyone was not given that opportunity). The extent to which students did not know what the titles meant would influence both the reliability and validity of the instrument. Some of the lack of internal consistency indicated by the high frequency of tied rankings reported above, may be due to the students' being unfamiliar with some of the course titles.

Prior Knowledge of Subject

As discussed in Chapter II, it was desired to evaluate the amount of background the students had in each of the four content areas without using a regular achievement test. The instrument developed consists of ten questions, and are the same for each content area except for changing the name of the content area. The questions can be answered with a simple "Yes" or "No."

The questionnaires are scored by assigning a numeric weight of 1, 2, or 3 to those answered yes according to their relative significance. The weights assigned are arbitrary and could have been assigned differently. The questions from the psychology questionnaire are shown below with the numeric weights for each.

	Question	Weight
1.	Have you ever been taught in school anything about psychology?	3
2.	Have you ever read a book about psychology?	3
3.	Have you ever read a magazine article about psychology?	2
4.	Is anyone you know a psychologist?	1
5.	Have you ever visited a psychological laboratory?	1
6.	Have you ever talked to a psychologist about psychology?	2
7.	Have you ever watched a psychologist work?	1
8.	Is your father or mother a psychologist?	3
9.	Do you ever talk about psychology at home with members of your family?	1
10.	Do you know what a psychologist does?	1

No attempt was made at establishing reliability for the instrument. While there is some face validity to the questionnaire, some of the items may give misleading results--especially for the psychology and statistics questionnaires. The popular conceptions of psychology and statistics tend to differ from the content of the programmed materials in the course, and familiarity with these popular concepts would not indicate knowledge of the program contents. Similarly, the specific contents covered by the titles of astronomy, computer programming, psychology, and statistics can be quite varied and knowledge of one type of content would not necessarily be related to the types covered in this study.

Achievement Tests

Four achievement tests were developed as criteria for measuring the effectiveness of the instructional material. The tests are identical for each version of the material within each content area and are in multiple-choice forms. The tests cover only the material presented in Part II and not Part I. Rather than preparing a complete table of specifications for each set of material, the nature of the programmed instructional material being in discrete frames permitted a random sampling of material to be tested. This method was more efficient than preparing a table of specifications and it probably more validly represents the material. In order to equally represent each version of the material, 100 of the orignal frames were randomly selected from each Part II of the materials--one frame from each page. This represents 1/8 of the total number of frames. Then a multiple-choice item was written to reflect the content of each of the selected frames. Frames for which test items were written were not screened to eliminate trivial content.

Since each test was to be given within a sixty-four-minute period, only 64 questions were included in the final versions of the tests. The 64 questions represent 8% of the 800 frames in each Part II and are allocated in such a way that they also represent 8% of the response frames (terminal frames in each unit) for each version of the material. That is, regardless of version, 8% of the frames which terminate a unit and which solicit a response are represented by a test question (this distribution will be different following item analysis). Table 3-1 illustrates the numerical allocation of these questions. Additionally, each of the eight paginal frame positions is equally represented by eight test items.

Table 3-1

Numerical Allocation of Achievement Test Questions
By Response Frames Across Versions

Version	No. of Frames Per Unit	Total No. of Units and Response Frames	Test Frames Coinciding with Response Frames	
			Number	Percentage
1	1	800	64	8.0
2	4	200	16	8.0
3	16	50	4	8.0
4	32	25	2	8.0

The selection of the questions in the final version of each test was based upon the following criteria:

1. Each of the responding versions is equally represented as described above.

2. Questions subjectively judged to be ambiguous or otherwise of poor quality were not used.

3. Questions were physically distributed as much as possible across the material for each of the responding frames.

Where these criteria were not adequate to choose between two or more questions, the choice was made randomly.

The resultant 64 questions for each test were then randomly ordered for the final version to eliminate the existence of any temporal ordering effect in terms of the amount of time which had passed since that part of the material was studied.

While all four tests were developed in the above manner, the initial development of the psychology test had taken place during a prior study (Flynn, 1968). At that time, nine test items were removed by item analysis as failing to discriminate and the resultant test had an internal consistency of .94 (Kuder-Richardson Formula 20). For the present study, each of these nine items was either replaced by a substitute item or it was rewritten. This revised instrument was designated as Form B of the Psychology Achievement Test.

The items in the four tests were analyzed to determine their ability to discriminate based upon the pooled responses of the students across treatment groups. In the previous development of the psychology test, the discrimination index used was the difference in the proportion of students in the upper and lower 27% of the sample getting each item correct (Flynn, 1968). However, in the present study the point-biserial correlation between the item and the total score was employed. Guertin (1965) discussed the problems associated with using the total test score as the criterion for item analysis and reported a computer program which periodically updated the total score as the items with the lowest correlations were eliminated. A program patterned after Guertin's was developed and used in the present study. This program differed from Guertin's in two main respects: First point-biserial correlation was used instead of biserial and second, the total score was revised after each item (or group of items with the same correlation) was eliminated rather than after 5% of the items were eliminated. As with Guertin's program, the rejected items were analyzed in a second pass to determine if they form an identifiable second dimension of the test. In both analyses for the four tests, items were dropped which had an absolute correlation of .25 or below with the total. The value of .25 represents the approximate .05 significance level for each of the four samples (although only one sample was used with repeated measures, some students did not complete all four tests resulting in a different N for each test).

Tables 3-2, 3-3, 3-4, and 3-5 show the results of the item analyses. The proportion of Ss getting each item correct is also reported although this was not used as a criterion for rejecting items since the discrimination criterion rejects those items which are too easy or too difficult. The relatively high number of items rejected in each test may be in part due to the fact that the tests were administered four weeks after the

Table 3-2

Items Retained Following Item Analysis of the Astronomy Achievement Test

Item	Percent Correct	Correlation		Item	Percent Correct	Correlation	
		I	II			I	II
1	94	---		33	50	.33	
2	34	.36		34	71	.32	
3	40	.37		35	75	.37	
4	30	---		36	67	.45	
5	67	---	.45	37	59	.62	
6	80	.42		38	36	.48	
7	44	---	.55	39	51	.35	
8	55	.41		40	34	---	
9	32	.37		41	28	.36	
10	15	---		42	44	.57	
11	53	.43		43	44	---	.35
12	63	.33		44	32	.34	
13	48	---		45	40	---	.37
14	69	.57		46	36	---	.42
15	17	---		47	65	---	
16	57	.53		48	46	.43	
17	57	.29		49	0	---	
18	63	.39		50	48	.34	
19	76	.42		51	55	.37	
20	59	.41		52	59	.62	
21	53	.58		53	5	---	
22	75	.46		54	59	.36	
23	32	---		55	[illegible]	.37	
24	26	---	.39	56	61	.32	
25	50	.28		57	71	.41	
26	50	.59		58	40	.37	
27	32	.32		59	69	.31	
28	17	---	.36	60	69	.33	
29	50	---	.40	61	30	---	.41
30	61	---	.49	62	69	.41	
31	50	.42		63	5	---	
32	21	.30		64	53	.39	

Table 3-3

Items Retained Following Item
Analysis of the Computer Programming Achievement Test

Item	Percent Correct	Correlation I	Correlation II	Item	Percent Correct	Correlation I	Correlation II
1	36	---	.26	33	10	---	
2	32	.47		34	40	.35	
3	32	.45		35	34	.41	
4	38	.37		36	34	.46	
5	36	.45		37	44	.30	
6	40	.37		38	36	.45	
7	26	.39		39	22	---	
8	44	.31		40	53	.31	
9	34	.45		41	57	.34	
10	51	.39		42	22	---	.41
11	48	.39		43	53	.41	
12	32	.32		44	18	.45	
13	42	.37		45	32	.37	
14	30	.33		46	16	---	.28
15	0	---		47	34	---	
16	42	.35		48	32	---	.41
17	42	---	.42	49	38	.50	
18	28	.50		50	48	---	
19	55	---	.48	51	16	.35	
20	40	.31		52	14	.41	
21	0	---		53	30	.41	
22	28	.56		54	32	.56	
23	42	.58		55	36	.50	
24	51	.34		56	32	.43	
25	26	.27		57	32	.40	
26	36	.32		58	10	---	
27	24	---	.57	59	30	---	.28
28	40	.27		60	36	.32	
29	51	.42		61	18	---	.34
30	26	---		62	44	.42	
31	2	---		63	51	.40	
32	59	---	.37	64	38	.47	

Table 3-4

Items Retained Following Item Analysis of the Psychology Achievement Test

Item	Percent Correct	Correlation		Item	Percent Correct	Correlation	
		I	II			I	II
1	43	.36		33	52	.48	
2	34	.53		34	13	---	.31
3	47	.26		35	50	.58	
4	13	---		36	21	.41	
5	47	.61		37	50	.41	
6	28	.40		38	30	---	.37
7	8	---		39	39	.50	
8	23	---		40	41	.61	
9	73	.40		41	50	.35	
10	32	---		42	17	---	
11	34	.37		43	32	.50	
12	28	---		44	41	.35	
13	34	.35		45	69	---	
14	41	.41		46	54	---	.52
15	54	---	.31	47	50	.43	
16	23	---	.40	48	45	.37	
17	34	---		49	34	---	.33
18	58	---	.28	50	23	---	
19	56	.46		51	45	.58	
20	34	--	.49	52	43	.41	
21	30	.33		53	39	.53	
22	50	---	.36	54	36	.29	
23	47	.49		55	65	---	
24	54	.60		56	41	---	.31
25	34	---	.45	57	6	---	
26	58	.43		58	47	.37	
27	19	---	.29	59	39	.28	
28	34	.42		60	50	.74	
29	47	.41		61	47	.55	
30	19	---	.34	62	17	---	
31	21	---	.33	63	17	.28	
32	41	---		64	50	.57	

Table 3-5

Items Retained Following Item Analysis of the Statistics Achievement Test

Item	Percent Correct	Correlation		Item	Percent Correct	Correlation	
		I	II			I	II
1	50	---		33	62	.61	
2	12	---	.34	34	8	---	
3	42	.54		35	16	.27	
4	68	.31		36	16	---	
5	24	.36		37	30	.34	
6	58	.33		38	24	.37	
7	26	---	.27	39	44	.40	
8	44	.35		40	52	.34	
9	38	.28		41	50	.36	
10	62	.31		42	52	.43	
11	30	.31		43	48	.61	
12	26	---	.39	44	50	---	
13	32	.42		45	22	---	.33
14	28	---		46	62	.47	
15	2	---		47	34	---	.27
16	16	---	.30	48	28	.39	
17	32	.30		49	10	---	
18	46	.42		50	66	.54	
19	44	.47		51	24	.28	
20	34	.34		52	44	.53	
21	56	.36		53	42	---	.28
22	40	---	.43	54	24	---	.28
23	34	.48		55	28	---	.31
24	32	.53		56	60	---	.37
25	6	---	.33	57	38	.35	
26	64	.42		58	14	.33	
27	24	---	.33	59	72	.59	
28	38	---	.26	60	62	.27	
29	26	---		61	30	.30	
30	34	.52		62	30	---	
31	60	.49		63	50	---	.40
32	26	.32		64	0	---	

students completed the relevant materials. Fewer items would have been rejected had the tests been given immediately. The delayed administration may also explain why a large number of items were rejected from the psychology test when it had been previously subjected to an item analysis.

After the item analyses, the internal consistencies of the tests were calculated using the Kuder-Richardson formula

$$r = \frac{k}{k-1}\left(1 - \frac{\Sigma piqi}{\sigma_x^2}\right)$$

where

r is the reliability coefficient,

k is the number of test items,

pi is the proportion of Ss getting item i correct,

qi is 1-p, and

σ_x^2 is the variance of the test scores.

The obtained r's are reported in Table 3-6. The consistently low r's for the second dimension on each test is probably due to the small number of items contained in these sub-tests. The number of items on these vary from 10 to 15. Because of the low reliabilities of the second dimensions of the tests (they range from .38 to .52), they can only be utilized for mean comparisons among groups. The variability is too great to use these scores as criterion variables in individual prediction. The coefficients obtained for the first and major dimension of each test are all in the high .80's and are considered quite adequate.

Table 3-6

Kuder-Richardson Coefficients for the Two Dimensions of the Four Achievement Tests

	Astronomy		Computer Programming		Psychology		Statistics	
	I	II	I	II	I	II	I	II
N	52	52	49	49	46	46	50	50
No. of Items	43	10	45	10	40	14	39	15
Mean	23.8	4.2	17.0	3.4	16.7	4.9	16.8	4.5
S.D.	8.4	2.0	8.6	1.7	8.2	2.4	7.6	2.1
r	.88	.50	.89	.38	.87	.52	.88	.41

Due to the method by which the tests were constructed, they can be expected to have relatively high content validity and no attempt was made to establish criterion-related validity. Each question was written to reflect the content of a specific frame and the internal consistency is reasonably high.

Attitude Scales

Four instruments were developed to measure student's attitudes toward the materials and the study following the completion of each program. Each instrument consists of nine 5-point Likert scaled items plus space for any additional comments the students wished to make. The instruments are identical for each content area except for changing the name of the area to the appropriate one.

Initially, it had been planned to create one composite questionnaire which would contain items comparing the different contents and versions. This was not done, however, because such a composite questionnaire would have to be given after the student finished all four programs and the amount of time lapsed between the completion of the material and the completion of the instrument would vary greatly within and between treatment groups.

In each content area, three factors were hypothesized. These are attitudes toward the specific content, attitudes toward the method of instruction, and attitudes toward the instructional situation. These are labelled Subject, Method, and General, respectively. The nine items were predicted to load on the factors as shown below:

	ITEM	FACTOR
(1)	I would like to read more about astronomy.	Subject
(2)	I would rather read a regular textbook on astronomy than have it taught by the materials I have just completed.	Method
(3)	I did not like the way astronomy was taught in the materials I have just completed.	Method
(4)	I would like to become an astronomer.	Subject
(5)	The booklets had a lot of mistakes in them.	General
(6)	The printing in the booklets was difficult to read.	General
(7)	There was too much confusion in the classroom while I worked.	General
(8)	I learned a lot about astronomy from reading the materials.	Subject
(9)	I would like to see these booklets become part of the regular course work at Nova High School.	Subject Method

While the above items are from the astronomy questionnaire, the corresponding items on the other questionnaires were predicted to load in the same way. Item 9 could be interpreted by the student as referring to either the subject or the content or both and could load on either factor. To a lesser extent, some of the other items might load on more than one factor. For example, Item 8, "I learned a lot about astronomy from reading the materials" could be answered either in terms of the student's reaction to astronomy or in terms of his reaction to the method. Similarly, elements of Items 2 and 3 could be interpreted as subject related in addition to being method related.

Each questionnaire was factor analyzed using a principle components program developed by International Business Machines, Inc. In all four cases, only three factors had eigenvalues greater than 1.0. These three factors accounted for 61% of the variance for astronomy, 62% for computer programming, 66% for psychology and 66% for statistics. The three factors for each instrument were rotated to varimax criterion. The resultant loadings with absolute values equal to or greater than |.35| are reported in Tables 3-7, 3-8, 3-9, and 3-10. In each table, the predicted items for each factor are indicated by boxes.

Table 3-7

Factor Structure of Astronomy Questionnaire Items and the Relationship to the Hypothesized Structure[a]

	Factor		
Item	General	Subject	Method
1		$\boxed{.85}$	
2	.59		$\boxed{-.38}$
3			$\boxed{-.61}$
4		$\boxed{.87}$	
5	$\boxed{.74}$		
6	$\boxed{.78}$		
7	$\boxed{.50}$		
8		$\boxed{}$	.82
9		$\boxed{.37}$	$\boxed{.76}$

[a] Boxes in table indicate where items were hypothesized to load. Only loadings equal to or greater than |.35| are reported.

Table 3-8

Factor Structure of Computer Programming Questionnaire Items and the Relationship to the Hypothesized Structure[a]

Item	Factor		
	General	Subject	Method
1		$\boxed{.80}$	
2			$\boxed{-.79}$
3		-.50	$\boxed{-.38}$
4		$\boxed{.78}$	
5	$\boxed{.75}$	-.38	
6	$\boxed{.85}$		
7	$\boxed{}$		$\boxed{-.55}$
8		$\boxed{.76}$	
9		$\boxed{.66}$	$\boxed{.51}$

[a] Boxes in table indicate where items were hypothesized to load. Only loadings equal to or greater than $|.35|$ are reported.

Table 3-9

Factor Structure of Psychology Questionnaire
Items and the Relationship to the Hypothesized Structure[a]

Item	Factor		
	General	Subject	Method
1	.46	$\boxed{.79}$	
2		.58	$\boxed{-.57}$
3			$\boxed{-.83}$
4		$\boxed{.93}$	
5	$\boxed{-.85}$		
6	$\boxed{-.54}$		
7	$\boxed{}$		-.60
8	.72	$\boxed{}$	
9	.71	$\boxed{}$	$\boxed{.35}$

[a] Boxes in table indicate where items were hypothesized to load. Only loadings equal to or greater than $|.35|$ are reported.

Table 3-10

Factor Structure of Statistics Questionnaire Items and the Relationship to the Hypothesized Structure[a]

Item	Factor		
	General	Subject	Method
1		$\boxed{.69}$	.39
2		.76	$\boxed{}$
3			$\boxed{.85}$
4		$\boxed{.78}$	
5	$\boxed{.80}$		
6	$\boxed{.86}$		
7	$\boxed{.41}$		.36
8			.79
9			$\boxed{.79}$

[a] Boxes in table indicate where items were hypothesized to load. Only loadings equal to or greater than $|.35|$ are reported.

As can be seen from the tables, there is high agreement between the obtained factors and the hypothesized factors. This agreement tends to validate the instrument, which in turn indicates good reliability. The instruments were not examined for reliability and validity beyond the factor analyses. In addition to the agreement between the hypothesized factors and the obtained ones, the scales appear to have face validity.

The instruments were scored on the basis of the hypothesized factors rather than the obtained ones. This was done because of the high agreement between the two sets and because comparable scores across instruments are desirable for interpretation. Thus, the ratings on each scale are weighted by 1 or 0 for each of the three factors depending upon its hypothesized inclusion or exclusion from that factor. Because of this method of scoring, the scores on the three factors will not be orthogonal to each other.

Other Data Collection Forms

In addition to the structured instruments described above, three other data collection forms were prepared. These are the Information Sheet, the Student Record Sheet, and the Non-Participation Response Sheet. Copies of these are also included in Appendix C.

The Information Sheet was filled out by the students on the first day of class. It includes spaces for their name, student number, Ad Com Room (i.e., homeroom), Ad Com teacher, grade, date of birth, number of years at Nova, and names of all courses in which they were currently enrolled.

The Student Record Sheet was used with the programmed materials for the student to record the book and version of materials he was working with the beginning and ending dates of both Part I and Part II and the number of errors made in both parts.

The Non-Participation Response Sheet was filled out by each student who formally dropped out of the Nova R project. It asked why they were not participating, if they would participate under other circumstances, and if they thought research should be conducted at Nova. It also solicited additional comments.

Chapter IV

ATTRITION AND THE RESULTANT SAMPLE

In relation to the goals of the study, the causes and effects of attrition warrant close examination for two important reasons. First it is important to ascertain if the attrition has affected the random assignment to treatment groups so as to invalidate or made uninterpretable the results obtained. Second, the causes of attrition may indirectly aid in attaining the objective of the study concerned with identifying characteristics of learners who succeed with programmed instruction. If some of the attrition is due to the learner's incompatibility with programmed materials, then it is important to identify the characteristics of such learners.

Distribution and Randomness of Attrition

For the purposes of analysis, three general categories of non-participants can be identified. These are (1) students who were not actually enrolled in school at the time of the study although they were on the class rolls, (2) students who showed up for the study but who dropped out before beginning work on the programmed materials, and (3) students who dropped out after beginning work on the programmed materials. Distinctions among these three categories are important in examining the attrition problem. Students in the first category can be considered as non-entities who have no effect on the sample or the study other than reducing the size of the original N. Students in the second category can be expected to alter the characteristics of the remaining sample and reduce its size by dropping out, but their absence should not generally influence the differences among treatment groups nor should their dropping out be considered as indications of negative reactions to the materials.

The attrition in the last category, however, is potentially a more serious problem. These students may have dropped out because of their experiences with the materials. Since the students in each treatment group started with a different set of materials it is possible that some treatment groups suffered greater attrition than others. If the attrition occurred unevenly across treatment groups, the characteristics of the resultant sample could vary greatly as a result. Thus, it is particularly important to study the nature and effect of attrition in the last category.

Table 4-1 shows the number of students in each of the three attrition categories as well as the number of students who finished. Also, the columns represent the treatment group to which the students were assigned. Students in Categories 1 and 2 who were assigned to treatment groups were unaware of their assignment and did not see the materials. The ten students of those not in school who were assigned to groups were assigned

Table 4-1

Distribution of Students by Completion Category and Treatment Group[a]

		Treatment Group					
Completion Category		0	1	2	3	4	Total
1. Not in School	Term 1	0	3	0	1	5	9
	Term 2	6	1	0	0	0	7
	Total	6	4	0	1	5	16
2. Did not Start Materials							
a. Not Assigned to Groups	Term 1	26	-	-	-	-	26
	Term 2	46	-	-	-	-	46
	Total	72	-	-	-	-	72
b. Assigned to Groups	Term 1	-	1	6	1	3	11
	Term 2	-	5	5	7	4	21
	Total	-	6	11	8	7	32
c. Category Total		72	6	11	8	7	104
3. Started Materials							
a. Finished no materials	Term 1	-	3	5	2	7	17
	Term 2		0	2	0	2	4
	Total	-	3	7	2	9	21
b. Finished 1-3 sets of materials	Term 1	-	4	0	2	4	10
	Term 2	-	0	0	0	0	0
	Total	-	4	0	2	4	10
c. Category Total		-	7	7	4	13	31
4. Finished All Materials	Term 1	-	8	9	6	7	30
	Term 2	-	2	3	7	3	15
	Total	-	10	12	13	10	45
	Grand Total	78	27	30	26	35	196

---

[a] Five students who were assigned to the second term requested and were granted permission to participate in the first term. They are included in this table in the first term figures.

on the possibility that they might arrive at a later time. However, they did not.

The information in the table is slightly misleading since the students in the second term were assigned to groups in order to fill them out and were not evenly distributed. Consequently, the figures cannot be directly pooled across terms for determination of randomness of attrition. Instead, comparisons within terms are more interpretable. Within each term, then, a comparison can be made across treatment groups between those who saw the materials and dropped out and those who completed all the work. These comparisons will permit the determination of the randomness of attrition across groups.

In the second term all of the students who started either dropped out before they completed any materials or they completed all of the materials. This was not true in the first term where ten students partially completed the materials (1 to 3 sets). These ten could logically be included with either the dropouts or the non-dropouts for comparison purposes. If the students in a treatment group who dropped out before completing any materials did so because of their experience with the first program in that sequence, then they may be different from the students who completed the first set and then quit later in the study. However, the students in both groups did drop out and can be considered collectively as dropouts. The way in which they are considered in determining the randomness of attrition is indicated by the analyses to be performed. If only the criterion data from students who completed all the materials is to be analyzed to determine treatment effects, then the partial completers should be considered as dropouts. If data from those who completed all and those who completed some materials is to be combined for analysis, then the partial completers should be considered as non-dropouts. Since both types of analyses are done, comparisons will be made both ways.

Tables 4-2, 4-3, and 4-4 show χ^2 contingency tables for the two first-term comparisons and the second term comparison. The χ^2's for

Table 4-2

First Term: Frequency of Students Starting Materials and Completing 0 Sets Versus Those Completing 1-4 Sets

	Treatment Group				
Sets Completed	1	2	3	4	Total
0	3	5	2	7	17
1-4	12	9	8	11	40
Total	15	14	10	18	57

$\chi^2 = 2.08$, d.f. = 3, n.s.

Table 4-3

First Term: Frequency of Students Starting Materials and Completing 0-3 Sets Versus Those Completing 4 Sets

	Treatment Group				
Sets Completed	1	2	3	4	Total
0-3	7	5	4	11	27
4	8	9	6	7	30
Total	15	14	10	18	57

$\chi^2 = 2.33$, d.f. = 3, n.s.

Table 4-4

Second Term: Frequency of Students Starting Materials and Completing 0 Sets Versus Those Completing 4 sets[a]

	Treatment Group				
Sets Completed	1	2	3	4	Total
0	0	2	0	2	4
4	2	3	7	3	15
Total	2	5	7	5	19

$\chi^2 = 5.35$, d.f. = 3, n.s.

[a]No students in the second term completed only 1-3 sets.

all three tables are not significant so there is no reason to believe the frequency of dropouts is not random across treatment groups. It will be noted that each of the three contingency tables have several cells with frequencies of less than five. While there is no correction factor for low frequencies in a contingency table larger than 2 x 2, the presence of low frequencies is not a serious problem here. The effect of low frequencies is to inflate the calculated χ^2 value which may cause rejection of the null hypothesis when it should not be rejected. In the three tables, the χ^2's were not significant so no problem was caused by the occurrences of frequencies below five.

While the rate of attrition appears to be random across groups, the possibility exists that the characteristics of the students vary across treatment groups. As reported previously, measures on several independent variables were taken and at least some data were collected on all of the 180 students who were in school. Table 4-5 shows the frequency of data collected by treatment group and completion status. As a test of the randomness of the resultant treatment groups, a discriminant function analysis was run among the groups using only those students who completed all four sets of material. The following 16 variables were used:

1. Age at beginning of study (in months)

Table 4-5

Distribution of Data Collected by Completion Category and Treatment Group

Completion Category	Treatment Group	N	Info Sheet	HSCS	Cog. Stl.	Read	Abil.	Bkgrd. Quest.
Did not start materials		104	104	29	29	7	8	29
Started - Finished None	1	3	3	2	2	3	3	2
	2	7	7	7	7	6	7	7
	3	2	2	2	2	2	2	2
	4	9	9	9	9	8	8	9
Started - Finished 1-3	1	4	4	4	4	4	4	4
	2	0	0	0	0	0	0	0
	3	2	2	2	2	2	2	2
	4	4	4	4	4	4	4	4
Started - Finished All	1	10	10	9	10	10	9	10
	2	12	12	12	12	12	12	12
	3	13	13	13	13	13	13	13
	4	10	10	10	10	10	10	10
Total		180	180	103	104	81	82	104

2. Sex
3. Number of years previously at Nova H.S.
4. Reading Comprehension (Nelson-Denny)
5. Vocabulary (Nelson-Denny)
6. Reading Rate (Nelson-Denny)
7. Mental Ability (Henmon-Nelson raw score)
8. Interest in astronomy (H.S.C.S.)
9. Interest in computer programming (H.S.C.S.)
10. Interest in psychology (H.S.C.S.)
11. Interest in statistics (H.S.C.S.)
12. Cognitive style (Pick Two Pictures)
13. Background in astronomy
14. Background in computer programming
15. Background in psychology
16. Background in statistics

Only 42 of the 45 students had complete data on all 16 variables and were used in the analysis. The ratio of 42 subjects to 16 variables is not as great as might be desired by some experts, but it exceeds 2:1 and can be expected to yield interpretable results. There was no overall significance (F was less than one, but not significantly so), and none of the univariate F's were significant either. Table 4-6 presents the means of each of the variables by treatment group together with the univariate F's. The discriminant function analysis, therefore, indicates that the student characteristics measured are randomly distributed across treatment groups and that the attrition did not adversely affect one group over another. Thus, in spite of the attrition, the treatment groups can be compared on the criterion measures as originally planned. The effect of attrition on the generalization of results is discussed later in this chapter.

Stated Reasons for Attrition

Each student who formally withdrew from the project was requested to complete a Non-Participation Response Sheet (see Appendix C). The form asked why the student was not participating, if he would participate if the project was conducted later in the year, if he would participate if the project was different in some way (and if so, how), and if he thought research should be conducted at Nova High School. Space was also provided for additional comments.

Table 4-6

Means and Univariate F-Ratios of the Treatment Groups on Sixteen Independent Variables[9]

Variable	Treatment Groups					
	1	2	3	4		
N	8	12	12	10	F	P
Age (months)	192.75	194.92	195.33	195.00	0.84	0.517
Sex (1-Male, 2-female)	1.50	1.58	1.58	1.50	0.09	0.966
Years at Nova H.S.	1.75	1.58	1.92	2.10	0.50	0.686
Reading comprehension	37.75	44.17	35.92	41.40	0.71	0.556
Vocabulary	28.75	36.58	30.75	32.70	0.46	0.712
Reading rate	298.62	290.83	300.83	290.10	0.02	0.994
Mental ability	58.00	63.17	58.92	57.90	0.51	0.679
Interest in astronomy	8.50	8.25	8.25	8.70	0.03	0.992
Interest in Comp. Prog.	9.00	11.3[illegible]	9.00	9.20	0.82	0.509
Interest in psychology	7.37	8.42	7.67	9.50	0.54	0.662
Interest in statistics	7.62	5.33	5.08	5.50	1.51	0.227
Cognitive style	9.62	9.08	10.00	9.60	0.07	0.975
Background in astronomy	7.25	7.92	8.58	9.10	0.53	0.666
Background in Comp. Prog.	5.75	4.08	3.25	6.90	1.49	0.232
Background in psychology	4.88	6.92	5.58	4.20	1.07	0.375
Background in statistics	3.50	2.00	2.25	1.90	0.56	0.651

[9] Two students in Group 1 and one student in Group 3 had missing data on one or more variables and were eliminated from this analysis.

Of the 135 students who were in school and who did not complete all four sets of materials, 96 completed Non-Participation forms (NP Forms). This means that the remaining 39 did not formally withdraw from the project, but were absent without explanation. Table 4-7 shows the distribution of completed NP Forms across the attrition categories. Of the five students who completed 1-3 sets of material but who did not finish and who did not complete an NP Form, three actually completed reading all four sets of programs but failed to take all of the achievement tests. Since the tests were scheduled four weeks after the completion of each unit, various problems could have contributed to the failure of these students to return for the tests. The remaining students who did not return NP Forms can only be classified as AWOL. While school officials were quite willing to cooperate with the project in making students return to class, it was not felt that coerced participation would be in the best interests of the research.

Table 4-7

Distribution of Completed Non-Participation Response Sheets by Attrition Category

Attrition Category	NP Form Yes	Completed No	Total
2a. Not Assigned to Groups	70	2	72
2b. Assigned-Did Not Start Materials	5	27	32
3a. Standard Materials-No Completion	16	5	21
3b. Completed 1-3 Sets	5	5	10
Total	96	39	135

The reasons given for not participating by the 96 students who completed NP Forms were classified into three general groups. The first classification consists of responses which expressed that participation imposed a time constraint on the student. These were of two sub-types: (1) the student needed the time for other school work and (2) the student had an existing schedule conflict with Nova R or he was going to sign up for another course. The first of these sub-groups is exemplified by statements such as "I need this time for other study" and "I am too far behind in my other subjects." The second had responses such as "Because I need to have varsity sports 11-12 mods which is when I have Nova R" and "I had to have another class scheduled into part of my Nova R time."

The second classification is of responses which express a negative reaction to the materials, to the contents involved, or to the project in general. Responses here can be grouped into three sub-classifications: (1) the student is not interested or does not like something about the project; (2) the student is not learning, the material is too difficult, or he does not understand it; and (3) the project is unimportant, it is a waste of time, or it is non-credit.

Responses classified in the first of these subgroups include "I am not interested in any of the required readings" and "I have not been participating to my fullest because of lack of interest in this project." Under the second subgrouping are "I feel I cannot learn through this method" and "I found this [learning psychology] very difficult using your booklets." In the third group are responses such as "the subjects to me was [sic] just a waste of my time" and "I figure I can find more productive things to do with my time."

The last category is the inevitable "other" which included two blind students plus a few other responses which do not readily fit into the other categories.

Table 4-8 presents the distribution of the various response types across the four classes of attrition. The total exceeds the 96 students who responded since 16 had responses which were classified in two categories. A fact which is readily apparent from the table is that most of the non-participants claimed that they needed the time for their other school work. If this in fact is true, then the possibility exists that these students must spend more time on their school work than those who remained in the project. This possibility and its implications are examined later in the chapter.

Table 4-9 summarizes the responses to the three questions on the NP Form. As the table shows, the vast majority of the dropouts were not willing to participate if the project were conducted later in the year and/or if it were different in some way. Most of the students believed that research should be conducted in Nova. The response distributions for none of the questions exhibit readily discernable trends across the four classes of attrition.

The explanation given by the 25 students who said that they would participate if the project was somehow different are summarized in Table 4-10. In general, the responses indicate that these students were not motivated to spend time reading through programmed materials in the four subject areas used.

One third of the students (32) wrote additional comments on their NP Forms. For the most part, these supplemented the other comments and provided no new information.

Range of Student Characteristics in the Sample

A final question to be asked about the attrition is how do the

Table 4-8

Classification of Reasons Given By 96 Students

For Not Participating[a]

REASON	ATTRITION CATEGORY[b]				TOTAL
	2a	2b	3a	3b	
Time Constraint					
1. Need time for other work.	55	3	12	3	72
2. Course conflict	7	1	0	1	9
Negative Reaction					
1. Uninterested-Don't like.	7	1	5	1	14
2. Not learning-too difficult.	0	0	5	0	5
3. Project unimportant.	0	1	1	2	6
Other	5	0	0	0	5
Total	76	6	23	7	112

[a] Totals do not add to 96 because of multiple responses by 16 students.

[b] See Table 4-1 for explanation of Attrition Categories.

Table 4-9

Summary of Students' Responses to Questions on the Non-Participation Response Sheet

ATTRITION CATEGORY	PARTICIPATE IF PROJECT WAS LATER IN YEAR?							PARTICIPATE IF PROJECT WAS DIFFERENT IN SOME WAY?							SHOULD RESEARCH BE CONDUCTED IN NOVA H. S. ?						
	YES		NO		NA			YES		NO		NA			YES		NO		NA		
	#	%	#	%	#	%	Tot	#	%	#	%	#	%	Tot	#	%	#	%	#	%	Tot
Not Assigned	9	12.9	60	85.7	1	1.4	70	17	24.3	49	70.0	4	5.7	70	54	77.2	12	17.2	4	5.7	70
Assigned - No Start	0	-	5	100.0	0	-	5	2	40.0	3	60.0	0	-	5	4	80.0	1	20.0	0	-	5
Started - Not Completed	1	6.2	15	93.8	0	-	16	4	25.0	12	75.0	0	-	16	14	87.5	0	-	2	12.5	16
Completed 1-3 Sets	0	-	5	100.0	0	-	5	2	40.0	3	60.0	0	-	5	2	40.0	3	60.0	0	-	5
Total	10	10.4	85	88.4	1	1.0	96	25	26.0	67	69.7	4	4.2	96	74	77.0	16	16.6	6	6.2	96

Table 4-10

Ways in Which 25 Students Wanted
Project to be Different Before
They Would Participate

How Different	Frequency
More Interesting	8
Credit Given-Career Related	6
Less Time Involved	2
Less Reading-Smaller Books	3
At Different Time	2
Taught Differently	1
Different Subjects	1
Enrichment-No Tests	1
No Reason Given	1
Total	25

students who dropped out differ from those who completed the study? A corollary of this question is can characteristics of the dropouts be identified which would enable the prediction of their dropping out? Reference to Table 4-5 shows that only limited data are available for most of the dropouts and thus, the possible analyses are also limited.

The first comparison made was among the students who started the materials and (1) finished none, (2) finished 1-3 sets, and (3) finished all 4 sets. A discriminate function analysis was run for these groups on 12 variables. The four measures from the High School Curriculum Survey were omitted from the analysis because of the relative lack of consistency of the measure among the dropouts (see Chapter III). The other variables are the same as those reported for the previous analysis in this chapter. There were missing data for a total of eight students in this analysis, giving a total N of 68. The students in each category were pooled across treatment groups for the analysis.

The overall F-ratio did not quite attain significance (F = 1.56, df = 24 and 108, and p = .065). However, because the purpose of this analyses is to determine the nature of the resultant sample and how it differs from the dropout group, the sub-analyses will be discussed in the absence of overall significance.

One extracted root was significant (χ^2 = 27.1, df = 13, p = .013). It had four loadings with absolute values greater than .50 and none between .20 and .50. The four high loading variables in order of magnitude are number of years at Nova H.S. (-.67), cognitive style (-.64), background in astronomy (+.52), and background in computer programming (+.51). Reference to Table 4-11 will show that these also are the only variables having significant differences in the univariate F-tests. The group centroids for the significant root are 8.4 for the group that finished no sets, 10.2 for those who finished 1-3 sets, and 10.5 for those who finished all 4 sets. The individual variable means in Table 4-11 help to clarify the relationships. The no-set group was higher than the other two groups in number of years at Nova and in cognitive style and was lower than the other two in background in computer programming. The group which completed all sets was higher than the other two in background in astronomy. Several post hoc explanations could be given for these findings and the interelationships of the variables involved. However, such explanations would be only speculation. The important point is that the groups do differ on these four variables.

In a previous section, it was pointed out that the majority of the reasons given by students for not participating in the study related to a need for more time for school work. This implies that the students who dropped out might have greater difficulty in completing their school work than the students who remained. If this is actually the case, then it may be that the dropouts are of lower ability than the non-dropouts. In Table 4-11, the mean ability for the dropouts is slightly lower than that for the non-dropouts, but not significantly so. Similarly, the dropouts are lower in reading comprehension, vocabulary, and reading rate than the non-dropouts, but again the difference is not significant. Thus, while there may be a trend for the students of lower ability to dropout, it is at best a weak trend.

Table 4-11

Means and Univariate F-Ratios of Students Who Started on Materials on Twelve Variables[a]

VARIABLE	NUMBER OF SETS COMPLETED				
	0	1-3	4		
N	16	9	43	F	P
Age (Months	193.56	193.78	194.67	0.42	0.661
Sex (1-Male, 2-Female	1.62	1.33	1.56	1.02	0.368
Years at Nova H.S.	2.81	1.89	1.86	6.32	0.003*
Reading Comprehension	35.12	32.44	39.56	1.23	0.298
Vocabulary	28.56	24.44	32.40	1.37	0.259
Reading Rate	266.62	281.89	293.16	0.40	0.677
Mental Ability	58.25	53.33	59.65	1.08	0.348
Cognitive Style	14.12	10.33	9.60	5.74	0.005*
Background in Astronomy	5.25	5.67	8.19	5.08	0.009*
Background in Comp. Prog.	1.69	4.78	4.72	3.37	0.039*
Background in Psychology	4.38	3.78	5.60	1.19	0.312
Background in Statistics	2.31	2.44	2.28	0.01	0.990

[a] Five students in the first category, one in the second, and two in the third had missing data on one or more variables and were eliminated from this analysis

*Significant at .05 level or beyond

Only very limited data were available for the vast majority of the students who dropped out prior to starting on the materials. Since all of these completed the information sheet, age, sex, and number of years at Nova were available. Since number of years at Nova showed a significant difference in the above analysis, a discriminant function analysis was run among the dropouts who did not start and the other three groups using the available three variables. This analysis yielded a highly significant overall F-ratio (F = 3.30, df = 9 and 416, and p = .001) and one significant root ($\chi^2 = 21.2$, df = 5, p = .001). Only number of years at Nova had a high loading on this root (.94) with the other two variables loading below .20. Also, only number of years had a significant univariate F-ratio as reported in Table 4-12. The means in Table 4-12 show that the first two groups were at Nova an average of half a year to a year longer than the other two groups who finished one or more sets of materials. The obvious speculation is that students who have been in the system longer know best how to manage the system and got out of the study.

Table 4-12

Means and Univariate F-Ratios of All Students on Three Variables[a]

Variable	Did Not Start on Materials	Number of Sets Completed 0	1-3	4	F	P
N	103	21	9	44		
Age (months)	193.63	193.76	193.78	194.70	2.16	0.094
Sex (1-male, 2-female)	1.58	1.62	1.33	1.57	0.77	0.516
Years at Nova H.S.	2.32	2.86	1.89	1.84	6.73	0.000*

[a] One student each in the first, third and fourth categories had missing data on one or more variables and were eliminated from this analysis.

*Significant at .05 level or beyond.

In summary, these analyses show that there were some measured differences among the students who dropped out and those who did not. In general these differences were small and limited to a few variables. However, differences in variables other than those measured in this study may well exist. It is reasonable to expect, for example, certain personality differences to exist between the groups. However, the attrition has had little effect on the ability variables measured and has not caused differences to occur among the treatment groups. [illegible]

Chapter V

DATA ANALYSIS

The data were analyzed to meed the objectives stated in Chapter I. In order to make multivariate comparisons, the basic analyses use only the students who completed all four sets of materials. As reported previously, 45 students were in this category. At the time of the analyses it was discovered that one of the 45 had taken the computer programming achievement test without having completed the Part II booklet. Accordingly, this student was excluded from the multivariate analyses. The resultant N's used in most of the analyses were 10 each in Groups 1 and 4, and 12 each in Groups 2 and 3.

Although the data were collected in a Greco-Latin Square design, the data cannot be analyzed so that the ordering effect is determined. This is because the data are not comparable across the four subject areas. For example, it is not meaningful to compare psychology test scores to astronomy test scores. Consequently, while the design was used to vary order from treatment group to treatment group, its effects, if any, cannot be removed statistically.[1]

The Effect of Unit Size

The first two objectives of the study are to answer the following two questions:

(i) If the unit size in linearly programmed instructional material is varied while all other material-centered variables are held constant, will there be a differential efficiency of learning regardless of the individuals involved?

(ii) Does the optimal unit size, if any, vary with the content of the program?

These questions can be answered by comparing the four treatment groups' performances on the criterion variables.

Four classes of criterion measures were collected. These are the achievement test scores, completion times, error scores, and attitude scale scores. Each of these were examined separately.

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[1] While analysis of variance within the Greco-Latin square design was suggested in the proposal, this analysis is not feasible because such an analysis would require the assumption that the materials and the criterion measures are comparable across subject areas.

The eight criterion test scores (two scores for each test - see Chapter III) were compared across treatment groups in a four group discriminant function analysis.[2] Overall significance was not attained (F = 1.44, d.f. = 24 and 96, and p = .11). The means, standard deviations, and univariate F-ratios are shown in Table 5-1. None of the univariate tests were significant either. Since the discriminant function among the groups on the 16 independent variables reported in Chapter IV was not significant, there is no indication that any of the treatment groups are biased. In brief, it seems to make no difference on the criterion test which version of material (unit size) was used by the students.

Table 5-1

Means, Standard Deviations, and Univariate F-Ratios of the Treatment Groups on the Criterion Tests

Tests		Treatment Groups					
		1	2	3	4		
N		10	12	10	12	F	P
Astronomy I	Mean	25.20	23.75	23.08	22.70	0.17	.915
	SD	7.56	9.40	5.54	9.42		
Astronomy II	Mean	5.50	4.00	3.75	3.40	2.15	.107
	SD	1.80	1.96	1.83	2.06		
Computer Prog. I	Mean	13.30	17.42	14.92	21.70	2.29	.092
	SD	4.69	9.38	3.79	9.68		
Computer Prog. II	Mean	3.00	3.92	3.50	3.10	.57	.644
	SD	1.48	1.85	2.33	.94		
Psychology I	Mean	14.60	17.33	20.50	15.50	1.11	.355
	SD	5.48	8.07	5.82	11.10		
Psychology II	Mean	5.50	5.08	4.17	4.80	.62	.608
	SD	2.69	2.84	1.46	1.72		
Statistics I	Mean	15.90	17.67	14.50	19.00	.89	.544
	SD	6.83	8.08	5.48	5.57		
Statistics II	Mean	4.30	4.42	4.25	4.50	.03	.993
	SD	2.37	1.89	2.62	1.28		

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[2] The computer program used was adopted from Veldman (1967).

It is reasonable to expect the programs which require more responses to require more time for completion and this is generally what occurs. Examination of the completion time means in Table 5-2 tends to bear this out although there are some reversals.

Table 5-2

Means, Standard Deviations, and Univariate F-Ratios of the Treatment Groups on Completion Times

		Treatment Groups					
Program		1	2	3	4		
N		10	12	12	10	F	P
Astronomy	Mean	268.70	79.83	101.17	115.40	18.92	.00
	SD	103.34	37.34	45.46	39.64		
Computer Prog.	Mean	98.20	275.67	286.75	127.50	9.50	.00
	SD	48.59	101.81	142.11	71.10		
Psychology	Mean	183.40	161.08	164.25	199.70	.50	.69
	SD	87.86	91.59	59.25	76.55		
Statistics	Mean	111.50	327.00	147.58	117.70	16.13	.00
	SD	50.50	101.30	99.54	52.96		

A discriminant function analysis was run among the four groups using the completion times as variables. There was strong overall significance (F = 12.08, d.f. = 12 and 98, and p = .000+). The three extracted roots are all highly significant. The χ^2's for the three roots and the loadings of the completion times are shown in Table 5-3. The mean completion times are graphed in Figure 5-1.

It can be seen from the univariate F-ratios and from the loadings on the roots that there were only slight differences for the psychology completion times. The pattern of psychology completion times as shown in Figure 5-1 differ considerably from those reported previously for the psychology program (Flynn, 1968) and summarized in Figure 2-1 (p. 14) in this report. This suggests that the U-shaped curve obtained previously may have been an artifact of that particular study. However, reference to Figure 5-1 shows that both the astronomy completion times and the statistic completion times for Version 4 are longer than for Version 3. It appears that the unit size differences when the respond elicitations are as infrequent as in Versions 3 and 4 are not particularly crucial and can be easily overcome by individual differences.

Table 5-3

Extracted Roots in Discriminant Function

Analysis on Completion Times

Program	Root 1	 2	 3
Astronomy	-.78	.44	.34
Computer Programming	.63	-.26	.58
Psychology	-.15	-.02	-.28
Statistics	.74	.49	.10
χ^2	56.29	28.34	11.35
df	6	4	2
P	.00	.00	.00

The number of errors made by the students as they work through each of the programs is in part a function of the number of response frames in each of the four versions of the material. In order to compensate for these differences in the possible number of errors, each student's error scores were converted to proportions of possible errors. This conversion should equate the error scores across the versions.

The means of the proportions of errors made are reported in Table 5-4. A discriminant function analysis was run using the proportion of errors made as variables among the four treatment groups. There was no overall significance in the analysis (F ratio = 1.34, d.f. = 12 and 98, and P = .21). Thus, on the converted error scores there were no differences across treatment groups.

As described in Chapter III each of the four attitude questionnaires administered to the students following the completion of each set of material was scored on three factors. These factors were named General, Subject, and Method. Thus, a total of twelve attitude scores were available on each of the students. A discriminant function analysis was run among the four treatment groups using the twelve attitude scores as variables. Two students who completed the four tests did not complete the attitude scales. Also, several students completed all of the attitude questionnaires, but did not complete all of the achievement tests.

Figure 5-1

Completion Times for Each Subject Area
by Treatment Group

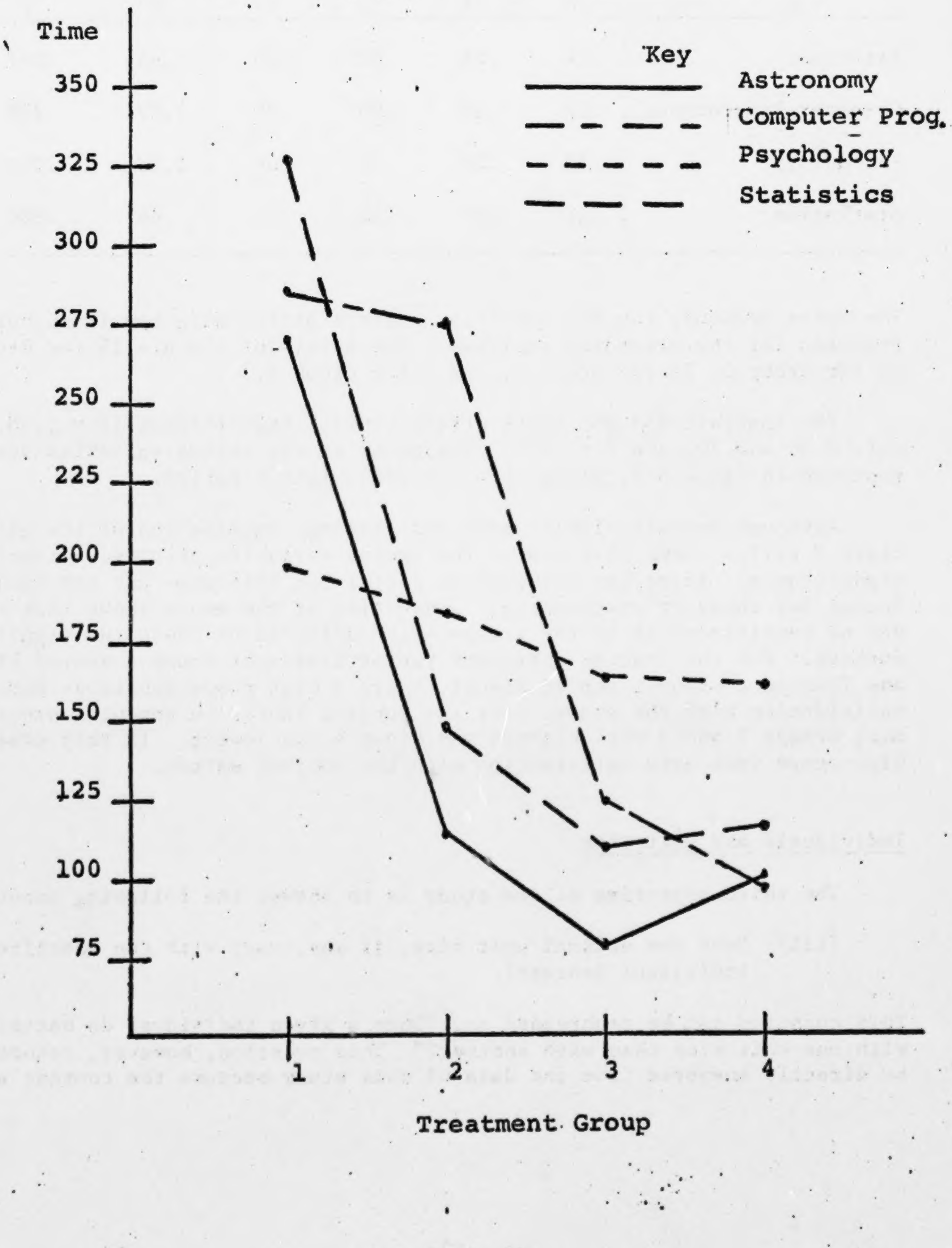

Table 5-4

Means and Univariate F-Ratios of the Treatment Groups on Proportion of Errors

Program	Treatment Groups 1	2	3	4		
N	10	12	12	10	F	P
Astronomy	.04	.04	.07	.05	.64	.597
Computer Programming	.12	.16	.09	.08	1.27	.298
Psychology	.10	.09	.16	.09	1.12	.353
Statistics	.12	.12	.11	.11	.06	.980

For these reasons, the N's for this analyses differ slightly from those reported for the preceding analyses. The resultant N's are 13 for Group 1, 11 for Group 2, 12 for Group 3, and 9 for Group 4.

The analysis did not quite attain overall significance (F = 1.48, d.f. = 36 and 89, and P = .07). The means of the twelve variables are reported in Table 5-5, along with the Univariate F ratios.

Although overall significance was lacking, examination of the univariate F ratios shows that two of the twelve variables attained univariate significance. These are the General factor for astronomy and the Subject factor for computer programming. Inspection of the means shows that there was no consistency as to the groups which differed on these two significant factors. For the General astronomy factor Treatment Group 2 scored highest and Treatment Group 1 scored lowest, where a high score indicates more dissatisfaction with the study. For the Subject factor in computer programming Groups 2 and 3 were highest and Group 4 was lowest. In this case a high score indicates satisfaction with the subject matter.

Individuals and Unit Size

The third objective of the study is to answer the following question:

(iii) Does the optimal unit size, if any, vary with the specific individual learner?

This question can be rephreased as, "Does a given individual do better with one unit size than with another?" This question, however, cannot be directly answered from the data of this study because the content area

Table 5-5

Means and Univariate F-Ratios of the Treatment Groups on the Twelve Attitude Factors

	Treatment Groups					
	1	2	3	4		
N	13	11	12	9	F	P
Astronomy						
General	11.38	13.91	11.75	12.44	3.20	.03
Subject	12.31	10.64	10.33	11.67	1.14	.34
Method	10.00	9.91	9.58	9.67	.19	.90
Computer Prog.						
General	11.54	10.00	10.67	12.11	2.01	.13
Subject	14.85	15.91	15.92	10.22	6.48	.00
Method	9.54	9.55	8.92	10.00	.87	.53
Psychology						
General	11.54	12.73	11.83	11.89	.61	.62
Subject	13.38	11.09	11.67	13.22	1.28	.29
Method	9.23	9.73	9.83	8.78	.62	.61
Statistics						
General	10.85	10.91	11.08	10.00	.28	.84
Subject	14.31	15.36	15.42	14.67	.33	.80
Method	9.92	8.36	10.00	9.89	2.44	.08

of the programs varies with the unit size for any given individual. Thus, comparison of an individual's performance across unit size is confounded by the content area and observed differences in performance can be attributable to either content or unit size or both. For instance, if a student in Group 1 performs better on the criterion test for astronomy than he did on the test for statistics, it could be because the subject matter is different, or because the unit sizes are different, or because both are different.

One indirect way in which some information can be obtained on this objective is to determine the degree to which the achievement test scores within treatment groups are correlated. If all of the correlations within a group are very high it will indicate that neither unit size or content make much difference to individual achievement. If all of the correlations are very low it will indicate that either unit size or content or both probably make a difference across individuals. If unit size is important within individuals, if the relationship can be summed across individuals, and if the relationship is linear and monotonic across units, then the correlations between adjacent unit sizes within a group will be larger than between non-adjacent unit sizes regardless of the contents. That is, the correlations between Versions 1 and 2 should be larger than between 1 and 3 or between 2 and 4 or between 1 and 4. Similarly, the correlations between 1 and 3 and between 2 and 4 should both be larger than that between 1 and 4.

Table 5-6 shows the intercorrelations among the four reliable achievement test scores within each of the treatment groups.[3] In none of the groups, can the correlations be consistently classed as very high or very low. In Treatment Groups 1 and 2, the correlations between Versions 1 and 2 are greater than among any other combinations, and the correlations of successive pairings decrease as predicted above if the optimum unit size varies for an individual. The relationship, however, tends to break down for Groups 3 and 4. In Group 3, Version 1 (in this case computer programming) is negatively correlated with the other versions and a stronger relationship exists between versions 1 and 3 than between 1 and 2. However, none of the correlations with Version 1 in Group 3 are significantly different than zero, so little faith can be placed in the stability of the trends exhibited. In Group 4, Versions 1 and 4 correlate substantially greater than do Versions 1 and 3. Similarly, Versions 2 and 4 correlated higher than do Versions 2 and 3. Thus, while the intercorrelations within Group 1 and 2 tend to indicate that individual variations occur systematically across unit sizes, the intercorrelations of Groups 3 and 4 do not substantiate this finding. The correlations in Group 4 are generally high and could indicate a non-monotonic relationship. In all of the groups, the N's are quite small and none of correlations can be considered highly stable.

High correlations among the different criterion test scores pooled across treatment groups would be evidence against the importance of unit sizes in influencing an individual's performance. Table 5-7 shows these intercorrelations for 41 students. All of the intercorrelations are significantly different from zero at the .05 level and they account for between 14% to 43% of the variance between tests (when corrected for attenuation, they account for between 18% to 56% of the variance). While these correlations are not excessively high, they do indicate that the differences in unit size and the differences in content are either not strong enough or not consistent enough to completely override the tendency for the scores on the different tests to vary together.

In brief, no definite conclusions can be reached concerning the third objective. While the evidence above suggests that individuals are not

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[3] In remaining analyses, only the four major criterion test scores will be used. The other four which were extracted from discarded items are not reliable enough for individual prediction.

Table 5-6

Intercorrelation Coefficients Among the Different Versions of Material by Treatment Group

Group	N	Version	1	2	3	4
1	10	1		.73	.58	.34
		2			.34	.23
		3				.75
		4				
2	12	1		.76	.62	.62
		2			.76	.65
		3				.52
		4				
3	12	1		-.06	-.16	-.10
		2			.48	.34
		3				.72
		4				
4	10	1		.86	.41	.84
		2			.35	.87
		3				.52
		4				

Table 5-7

Intercorrelation Coefficients Among the Four Subject Areas Across Treatment Groups

	1	2	3	4
1. Astronomy		.44	.65	.65
2. Computer Programming			.38	.55
3. Psychology				.56
4. Statistics				

greatly affected by unit size, it does not suggest that unit size has no effect. The results are at best equivocal. All of the above approaches are indirect and assume that the relationship is the same for all individuals. There is nothing in the above evidence to either confirm or deny the importance of unit size to a given individual.

Individual Prediction of Success

The last objective is to answer the following question:

(iv) Can learner-centered variables be identified which will enable accurate predictions of success to be made with respect to frame size (unit size) and content?

In other words, can predictions be made to determine how well a given individual will perform with a given content and unit size among those used in the study? To answer this question, each of the four major criterion test scores were used as criterion variables in separate multiple linear regression analyses with the various learner-centered variables discussed earlier used as predictors. Forty-one students had no missing data and were used in all of the regression analyses.

Although no significant differences were found previously among the treatment groups on the achievement test scores, unit size is included in the question and it may still be an important factor in prediction. Ideally, a different regression analysis should be made for each subject area in each treatment group for a total of 16 analyses. However, this is not feasible because of the small N's in each group (also such a large number of regression equations would be difficult to interpret meaningfully). Instead, unit size was taken into account by including the version number of the material as one of the predictor variables. The version numbers range from 1 to 4 increasing as unit size increases. Using version number as a predictor in this way assumes that the relationship between unit size and the criterion test scores is at least monotonic, if not linear. Yet one of the reasons why the particular unit sizes used were chosen was to capitalize on the maximums and minimums represented in the U-shaped curve of criterion test scores across treatment groups in the earlier study with the psychology materials (Flynn, 1968) as discussed in Chapter II. While no significant differences were found in either the previous study or in the present study across treatment groups, the possibility still exists that a non-monotonic relationship exists between unit size and criterion test scores. If this is the case, the use of the version number as a predictor in the regression equation may not contribute as much to the prediction as it actually should.

The use of the version numbers as predictors rather than the number of frames comprising a unit may also have an effect on the prediction. Version numbers range from 1 to 4 while the numbers of frames comprising units range from 1 to 32; however, in both cases, only four points are represented. Use of the number of frames in a unit as the measure would require the assumption that the number of frames in a unit is linearly related to the learning efficacy of the programs--that the ratio scale on which the frames are counted is isomorphic with a ratio scale of the effects produced. Using the version number, on the other hand, assumes only an ordinal scale of unit sizes. It is probable that neither the numbers representing the version nor the numbers representing the frames in a unit are the best measures of the qualitative effects of the different unit sizes, but they are the only plausible alternatives. Of these two, the version number is the most defensible.

In addition to the learner-centered variables and version number, completion time and proportion of errors were used in the first model as predictors. Thus, for each of the four criterion tests, a total of 19 predictors were used. For example, when the astronomy achievement test scores were used as the criterion variable, the following predictor variables were used:

1. Age in months
2. Sex (1 for male; 2 for female)
3. Years at Nova High School
4. Reading Comprehension
5. Vocabulary
6. Reading rate
7. Mental Ability
8. Cognitive Style
9. Interest in Astronomy
10. Interest in Computer Programming
11. Interest in Psychology
12. Interest in Statistics
13. Background in Astronomy

14. Background in Computer Programming
15. Background in Psychology
16. Background in Statistics
17. Astronomy Completion Time
18. Proportion of Errors made in Astronomy
19. Version Number for Astronomy

Variables 9 through 16 were used with each of the criterion variables even though they are specific to individual programs. Thus, the first sixteen of these predictor variables were used with each of the four criterion variables while the last three were changed to the corresponding measures for the specific achievement test.

Since the last three variables are not independent learner-centered ones, they were systematically dropped in two additional models to determine the amount of their contribution to the prediction equation. Hence, after the full regression model was analyzed as described above, a reduced model for each of the four criterion variables was created by omitting the version number as a predictor. A second reduced model was then used which omitted completion time and proportion of errors as well as version number. Tests were made across the three models to determine if the reductions were significant or not.

The regression program used was adapted from Veldman (1967). This program uses an interactive procedure in which the variable with the largest zero-order correlation with the criterion is selected first from the predictors. Additional iterations either select the variable which will maximally increase R^2 or readjust the weight of one of the predictors already selected to maximally increase R^2. Thus, the maximal contributors can be identified by examining the order in which variables are selected for inclusion in the equation. The Beta weight assigned to a variable does not necessarily mean that the variable would contribute to the prediction in the same way if the other predictors varied.

The Beta weights and R^2's for each of the three models for the four criterion variables are reported in Tables 5-8, 5-9, 5-10, and 5-11.[4] As is evident from the tables, there is some variability across the four subject areas; variables which are good predictors in one of the four subject areas are not necessarily good predictors in other areas.

The most striking observation to be made from the tables is the high degree of prediction achieved with the full models for each of the criterion tests. The R^2's respectively for astronomy, computer programming, psychology, and statistics are .81, .67, .80, and .75. These are all at or near the limit of prediction permitted by the reliability of the tests. In Chapter III, Kuder-Richardson coefficients were reported for the four tests of .88, .89, .87, and .88 respectively. Squared these values are .77, .79, .76, and .77. Thus, in the case of the astronomy test and the psychology test the predicted variance exceeds that predicted by the test itself and for statistics the predicted variance is

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[4] Raw score weights are not reported since they are metric dependent and cannot be directly interpreted.

Table 5 - 8

Beta Weights Obtained with Three Regression Models
Using Astronomy Achievement Test Scores Criterion

Variable	Model 1	Model 2	Model 3
Age	.06	.10	.03
Sex	-.12	-.13	-.06
Years at Nova	-.08	-.05	-.12
Rdg. Comprehension	.06	-.03	.00
Vocabulary	.27	.30	.21
Reading Rate	-.40	-.38	-.35
Mental Ability	.50	.53	.53
Cognitive Style	.07	.11	.09
Interest - Astronomy	.51	.48	.54
Interest - Comp. Prog.	-.06	-.01	.01
Interest - Psychology	.06	.06	.08
Interest - Statistics	-.16	-.19	-.09
Background - Astronomy	-.19	-.13	-.17
Background - Comp. Prog.	.44	.29	.38
Background - Psychology	.05	.06	.04
Background - Statistics	-.07	-.07	-.08
Completion Time	.46	.29	-
Proportion of Errors	-.06	-.05	-
Version Number	.33	-	-
R^2	.81	.76	.70

F-Tests:

Model 1 vs Model 2: F = 6.72, df = 1 and 27, p = .01
Model 2 vs Model 3: F = 3.50, df = 2 and 28, p = .05
Model 3 vs zero : F = 7.15, df = 10 and 30, p = .00

Table 5 - 9

Beta Weights Obtained with Three Regression Models
Using Computer Programming Achievement Test Scores Criterion

Variable	Model 1	Model 2	Model 3
Age	.21	.23	.27
Sex	.11	.07	-.01
Years at Nova	.11	.12	.12
Rdg. Comprehension	-.12	-.15	-.21
Vocabulary	.37	.38	.50
Reading Rate	-.31	-.33	-.35
Mental Ability	.34	.37	.35
Cognitive Style	.18	.16	.16
Interest - Astronomy	.13	.11	.09
Interest-Comp. Prog.	.18	.17	.15
Interest - Psychology	.23	.24	.24
Interest - Statistics	.10	.09	.09
Background-Astronomy	-.10	-.07	.03
Background-Comp. Prog.	.46	.40	.43
Background-Psychology	.06	.08	.03
Background-Statistics	-.16	-.12	-.07
Completion Time	-.20	-.09	-
Proportion of Errors	-.12	-.17	-
Version Number	-.12	-	-
R^2	.67	.66	.64

F-Tests:

Model 1 vs Model 2: F = .31, df = 1 and 27, p = .59
Model 2 vs Model 3: F = .88, df = 2 and 28, p = .55
Model 3 vs zero : F = 5.36, df = 10 and 30, p = .00

Table 5 - 10

Beta Weights Obtained with Three Regression Models
Using Psychology Achievement Test Scores Criterion

Variable	Model 1	Model 2	Model 3
Age	.17	.16	-.02
Sex	-.28	-.29	-.03
Years at Nova	.19	.15	.25
Rdg. Comprehension	.09	.08	.21
Vocabulary	.40	.39	.47
Reading Rate	.18	.17	-.07
Mental Ability	.11	.14	.19
Cognitive Style	.15	.13	.14
Interest-Astronomy	.01	-.01	-.05
Interest-Comp. Prog.	.04	.08	.24
Interest-Psychology	-.07	-.12	.12
Interest-Statistics	-.10	-.14	-.04
Background-Astronomy	.19	.15	.30
Background-Comp. Prog.	-.25	-.30	-.12
Background-Psychology	-.06	.05	-.08
Background-Statistics	-.08	-.11	-.02
Completion Time	.64	.63	-
Proportion of Errors	.04	.02	-
Version Number	.21	-	-
R^2	.80	.77	.59

F-Tests:

Model 1 vs Model 2: F = 3.30, df = 1 and 27, p = .08
Model 2 vs Model 3: F = 11.05, df = 2 and 28, p = .00
Model 3 vs zero : F = 4.36, df = 10 and 30, p = .00

Table 5 - 11

Beta Weights Obtained with Three Regression Models Using Statistics Achievement Test Scores Criterion

Variable	Model 1	Model 2	Model 3
Age	.16	.18	.18
Sex	.12	.23	.25
Years at Nova	.00	.00	.00
Rdg. Comprehension	-.16	-.06	-.06
Vocabulary	.11	.06	.03
Reading Rate	.27	-.25	-.27
Mental Ability	.67	.66	.70
Cognitive Style	.12	.21	.19
Interest-Astronomy	.25	.34	.37
Interest-Comp. Prog.	-.09	-.08	-.10
Interest-Psychology	-.15	-.02	-.05
Interest-Statistics	.05	.18	.17
Background-Astronomy	-.13	-.03	-.08
Background-Comp. Prog.	.33	.57	.57
Background-Psychology	.45	.26	.28
Background-Statistics	-.32	-.29	-.33
Completion Time	.36	.02	-
Proportion of Errors	-.10	.08	-
Version Number	.46	-	-
R^2	.75	.70	.69

F-Tests:

Model 1 vs Model 2: F = 5.45, df = 1 and 27, p = .03
Model 2 vs Model 3: F = .18, df = 2 and 28, p = .84
Model 3 vs zero : F = 6.74, df = 10 and 30, p = .00

Table 5-12

Correlations Between the Predictor Variables and the Four Criterion Test Scores Across Treatment Groups[a]

	Criterion Test			
Variable	Astron.	Comp.Pg.	Psychol.	Stat.
Age	-.16	.03	-.02	-.09
Sex	-.20	-.20	-.06	-.05
Years at Nova	-.04	.14	.06	.11
Reading Comprehension	.42*	.30	.56*	.43*
Vocabulary	.50*	.52*	.63*	.50*
Reading Rate	.06	.13	.23	.16
Mental Ability	.58*	.53*	.60*	.60*
Cognitive Style	.16	.10	.20	.15
Interest - Astronomy	.32*	-.13	.02	.19
Interest - Comp. Prog.	.16	.17	.11	.03
Interest - Psychology	-.00	.19	.12	.12
Interest - Statistics	-.19	-.08	-.08	-.03
Background - Astronomy	.08	-.00	.07	.16
Background - Comp. Prog.	.30	.46*	.12	.32*
Background - Psychology	.03	.03	.12	.26
Background - Statistics	-.06	-.09	-.10	-.10
Completion Time	.12	-.14	.50*	.32*
Proportion of Errors	-.26	-.35*	-.17	.01
Version Number	-.04	.02	.16	.08

[a] N = 41. * Indicates significance at .05 level. (The critical value of r at the .05 level for 39 degrees of freedom is .31.)

almost the same as that predicted by the test. The answer to the question for the fourth objective is a definite yes--accurate predictions of success can be made. With the astronomy and statistics programs, inclusion of version number as a predictor causes a significant increase in R^2; in both cases it accounts for 5% of the variance. In the computer programming and psychology programs it does not contribute significantly accounting for 1% and 3% of the variance respectively.

Removing the variables of completion time and error rate (Model 3) causes a significant drop in R^2 for astronomy and psychology, but not for the other two. Examination of the Beta weights indicates that this loss was due primarily to completion time rather than error rate. All of the equations for the third models still have significant and rather large R^2's, ranging from .70 for astronomy to .59 for psychology.

In all of the programs except psychology, mental ability has the largest zero-order correlation. For psychology, vocabulary has the largest (.63 versus .60). For astronomy, examination of the Beta weights shows that the best predictors in order of size (full model) are interest in astronomy, mental ability, completion time, background in computer programming, and reading rate. The large Beta weight assigned to background in computer programming is an enigma. It also has relatively large weights assigned to it for each of the other criterion tests. This may indicate that prior experience in that area as measured by the questionnaire used is related to some otherwise unmeasured, but relevant, variable. Similarly, large weights were assigned to seemingly irrelevant variables in some of the other equations.

For computer programming, the largest Beta weights are assigned to background in computer programming, vocabulary, mental ability, and reading rate. The weight assigned to reading rate for computer programming and for astronomy are negative indicating that fast reading corresponds to lower test scores (see also Table 5-12).

With the psychology test, the largest weights are for completion time and vocabulary. Also relatively large weights are assigned to sex and background in computer programming.

The largest weights for statistics are for mental ability, background in computer programming, and background in statistics. The presence of background in psychology as the second largest predictor of statistics test scores is also enigmatic--especially since it has an extremely small weight in predicting psychology test scores. Since the regression equations do not reveal the relationships between individual predictors and the criterion test scores, Table 5-12 contains the correlation coefficients between each of the predictors and the test scores. To conserve space, the intercorrelations of the predictor variables are not shown. Only the correlations with mental ability and vocabulary are consistently high across the four tests, with reading comprehension high for three of the four. The correlations with version number are generally very low.

While not significant, the correlations with sex are all negative indicating that the males tended to achieve higher scores than the females. This is probably a function of the nature of the subject matter.

Effect of Students Enrolled in Computer Science

Only one course of those in which the students were enrolled at the time of the study was directly related to the programmed materials. Four students among those who were included in the analyses reported in this chapter were enrolled in computer science. The computer science course at Nova High School teaches both FORTRAN and COBOL and information was not obtained as to which language the four were taking. Two of the four had had computer science also the previous year and this was reflected in their answers on the background questionnaires.

Three of the four were assigned to Treatment Group 4 and the other one to Group 1. Two of the three in Group 4 had scores on the computer programming test (major factor) of about two standard deviations above the overall mean while the third scored almost three standard deviations above the mean. The score of the single student in Group 1 was about at the mean. The high scores of these three in Group 4 undoubtedly account for the mean in that group being higher than the means for the other groups as shown in Table 5-1. Removal of these students from Group 4 would reduce the mean for that group from 21.70 to 15.86. Since the other means are 13.30, 17.42, and 14.92, removing these students still would not produce significant differences among the treatment groups and would probably merely reduce the size of the obtained F-ratios.

Two of the three also scored well above the overall mean on the other three tests--one was consistently two standard deviations above and the other was consistently one standard deviation above. Similarly they scored two and one standard deviation respectively above the mean on the mental ability test. The third student, however, was below the mean on all of the other achievement tests and the mental ability test. Hence, the high scores of two of these students cannot be entirely attributed to the computer science course. Since no significant differences were found among the groups on either computer programming or the other achievement tests, the analyses were not rerun without these students.

Another possible effect of having these students in the study is the failure of the regression equations for computer programming to produce as large an R^2 as was produced with the other three tests. Since it is likely that at least some of the variance in the test scores of these students was produced by their enrollment in computer science as part of their regular course work, it is likely that this accounts for at least some of the unpredicted variance in the total test scores in computer programming.

Chapter VI

DISCUSSION AND CONCLUSIONS

The major finding of this study is that the different unit sizes in programmed instruction did not produce statistically significant differences on the delayed achievement tests in any of the four content areas studied. This finding answers the questions asked for the first two objectives of the study (see page 8). Further, these findings support the conclusions of the previous study (Flynn, 1968) in which the unit size was varied on the psychology materials employed in the present study and no differences were found among the groups on an immediate achievement test.

There are several important considerations that should be kept in mind when interpreting these results. First, the research situation varied somewhat from the regular classroom situation in which extrinsic motivation in the form of grades and eventual graduation is present. This motivation was not present in the study, and the effects of its absence cannot be determined. That is, there were no contingencies on the students' performance; there were no rewards or punishments regardless of how well or how poorly they performed. Thus, the possibility exists that had such contingencies been present, significant differences might have emerged among the groups. (Further, such contingencies might have prevented the high attrition rate which occurred.) Of course, there are many situations in which someone might use programmed materials in the absence of such contingencies.

Another consideration is that while the discriminant analysis failed to detect significant differences among groups, the version number added significantly to the R^2 obtained in the regression analysis with two of the four criterion variables. This significant increase in R^2 suggests that for these two programs, the unit size did contribute to the students' achievement test scores in a consistent fashion across students. In neither case, however, is unit size (version number) a major predictor of the test scores; the increase in R^2 in both cases is .05 and the zero-order correlations are -.04 and .08. Further, very high predictions were still obtained when version number was removed from the equation.

Obtaining significant differences across groups and having the version number or unit size be a significant predictor requires that the differences in unit size produce similar effects with different individuals. If each person reacts differently to variations in unit size, a statistical test of differences among treatment group means would probably yield the same results as those which would be obtained if the variations in unit size made no difference for anyone. In both cases, no significant difference would be the expected outcome.

A third consideration, then is that the finding of no significant differences is based upon pooled student scores within treatment groups. Consequently, definite conclusions cannot be drawn regarding any one individual performance with different sized units in programmed instruction. The third objective was included to cover this situation, but the third objective was not answered with any definitiveness. This objective was to determine whether or not a given individual could do better with one unit size than with another. Only indirect evidence was available, and this evidence only shows that no strong trend is evident across individuals. Thus, the possibility exists that a given individual will do better with one unit size instead of another, even though the differences are not consistent across individuals.

The prediction equations obtained for each of the achievement tests were mentioned above. The high R^2's obtained answer the question asked as the fourth objective with a definite yes. With the astronomy, psychology, and statistics tests, better prediction would require more reliable tests than those used, even though the ones used have reliabilities ranging from .87 to .89.

An important implication of the prediction equations is that individual differences account for most of the variance of achievement test scores. This indicates that programmed instruction does not level out individual differences. As has been found to be true in many other learning situations, mental ability was found to be the best single predictor of performance on the achievement tests. Reading skills were found to be the next best single predictors.

The high attrition rate in the sample was unfortunate because it eliminated the cross-validation which had been built into the original design. In addition to providing a replication of study in general, such cross-validation would have been particularly beneficial in assessing the stability of the regression equations obtained. These equations should be verified in a future study.

Another effect of the attrition was to reduce the range of the characteristics of the students in the sample. The extent of this restriction cannot be fully determined because only limited data are available for the most of the dropouts. It was determined, however, that the attrition did not adversely affect differences between treatment groups.

The general conclusion to be drawn from the findings is that the reservations expressed in Chapter I about PI being the classroom counterpart of the laboratory operant conditioning situation are supported. This is especially true regarding the reinforcement qualities of responding and the associated feedback. If a high frequency of responding facilitated the learning of materials, then Treatment Groups 1 and 2 should have greatly surpassed 3 and 4. This, of course, was not the case.

Further support for the position that PI is not a direct counterpart of operant conditioning is provided by the general failure of error rate to contribute to the prediction equations. A tenet frequently espoused by advocates of Skinnerian programming is that errors made by the students should be minimized (e.g., Skinner, 1958). Yet, correlation in the present study between errors and achievement range from .01 for statistics, to -.35 for computer programming and only the one for computer programming is significantly different from zero. Except for statistics, the correlations were negative, which does indicate the presence of a trend that the more errors made, the lower the score attained. This is not a simple relationship, however, because other variables may influence both error rate and achievement.

The possibility exists that the problem is not with PI per se, but with the particular manifestations of PI studied. That is, an ideally constructed program might produce results that would be predicted by operant conditioning principles, even though the programs employed in this study did not. This leads to another consideration: Since four specific programs were used in the study, the degree to which the results can be generalized to other programmed materials is not known. Since only linear programs were used, the findings are not directly applicable to other kinds of programming such as branching. Since the programs were deliberately selected as being novel to the high school curriculum, it is not known exactly what the results would have been with less exotic programs. However, existing programmed instructional materials are quite numerous and the potential programs are infinite and it is only feasible to work with a small number of these in any experimental research. Consequently, there is no practical alternative but to assume the results hold for other programs until contrary results are obtained. Further, the fact that the same results were obtained across all four programs is a good argument for generalizing from the study.

None of the findings of this study provide guidelines for the teacher implementing PI in the classroom. No comparisons were made between PI and other types of instruction and no conclusions can be made as to whether a student will do better with PI than with something else. However, a key recommendation to be made following this research is for curriculum developers to seek a better approximation to the application of reinforcement and operant principles to instructional materials than is evident in the four programs studied.

A second recommendation to curriculum developers is to consider modifying PI materials to reduce or eliminate responding unless it can be demonstrated to have value in some situations. If students can do as well with very limited responding as they do with frequent responding, as was the case in this study, then there is little need for the responding. Not only did responding fail to increase performance on the achievement tests, but completion time is considerably longer when responding is required.

Several recommendations can be made for additional research to directly follow this study. The first of these is to replicate the study. All research should be replicated and particularly so in areas such as the teaching effectiveness of curriculum materials. Also, the study should be repeated using new programs and different student populations. Further, various types of criterion measures of achievement should be employed such as those originally proposed for the present study of immediate achievement tests, delayed achievement tests, and transfer tests.

Also, replications should be made in which the students are operating under some externally imposed contingency for success such as grades or money. Such contingencies usually exist in the classroom where materials such as those studied are likely to be used.

Another recommendation for further research is the study of individual students to determine if different unit sizes have differential effects on a given person. If they do, and if these effects are different for different individuals, then the next logical step is to determine if learner characteristics can be identified to predict the type of effect the varying sized units have. This step is necessary if guidelines are ever to be provided to the classroom teacher for the implementation of PI.

Appendix A

Letter to Student with Parental Permission Sheet

NOVA UNIVERSITY COLLEGE AVENUE, FORT LAUDERDALE, FLORIDA 33314 • 305/587-6660

August 8, 1968

Dear Student:

You have been scheduled into a special section along with many other tenth graders at Nova High School. You and the other students are being asked to take part in a project which is designed to evaluate several different sets of curriculum materials. You will be asked to read booklets on astronomy, computer programming, psychology, and statistics. This project is being conducted with the cooperation of the administration of Nova High School to determine how well these materials will teach. The information gained from this type of research will help in making decisions which will strengthen the school program at Nova and at other schools.

All of the work done in this section can be done during the class hours. There will be no work to be taken home and no outside reading or studying so that the time the student expends on this project will be at a minimum. This section, because of its diversity of subject matter, can be thought of as an enrichment course to the curriculum. If you are interested, you can be given supplementary reading materials in these subjects to pursue at your leisure.

Since this project is an addition to the regular requirements of Nova please have your parents (or guardian) read this letter and indicate their approval of your participation. Then return this sheet to the first meeting of the class or mail it to me at the address shown below.

Thank you.

SINCERELY,

John M Flynn

John M. Flynn
Nova University

Parental Permission Sheet:

Dear Parent: Please check one of the statements below:

_____ Yes, my child will participate in the project described above.
_____ No, my child will not participate in the project described above.

Signed ____________________

Date ____________________

Student: Please bring this sheet to the first meeting of the class or mail it to

Dr. John M. Flynn
Nova University
College Avenue
Ft. Lauderdale, Florida 33314

Appendix B

Programmed Materials

Four commencial programs were modified for use in the study. Brief descriptions of the content of these programs are given below. These descriptions only cover the content of the portion of the programs used in the study. Full references to the originals are given in the bibliography.

1. Descriptive Astronomy adapted from Programmed Astronomy I: The Solar System by Neil E. Sullivan and M. W. Sullivan. Copyright held by Sullivan Associates.

   This program deals with the solar system. The Earth and its moon, including their relationship to the sun, are the main topics. Additionally, information is presented on the two inner planets (Mercury and Venus) and on Mars. The other planets are not covered. Some information on the sun is included. The following introduction was given in the book:

   > "With this book the student should be able to instruct himself in introductory descriptive astronomy. Astronomy is concerned with the study of celestial objects beginning with the Earth and extending to the far reaches of the Universe. This book is designed to present the elementary terms and concepts of descriptive astronomy. In particular, the book deals with the solar system and the planets closest to the Earth."

2. Computer Programming: FORTRAN adapted from Introduction to FORTRAN by S. C. Plumb. Copyright held by McGraw-Hill Book Company. The basic concepts of FORTRAN are covered. The presentation is oriented toward the IBM system/360 computers (this orientation was a modification made when the material was prepared for the study). Topics covered include constants, variables, expressions, arithmetic formula statements, READ statements, and WRITE statements. Several aspects of FORTRAN were not presented and the student was advised that "additional information will probably be required before operational computer programs can be written." The following introduction was given in the book:

   > "With this book the student should be able to instruct himself in the fundamentals of FORTRAN. FORTRAN stands for FORmula TRANslation and is a language for writing programs for electronic computers. Programs are written for the purpose of leading the computer step-by-step through the solution of a problem. This book provides the basic concepts of FORTRAN and is oriented in parti-

cular toward the Basic FORTRAN for IBM System/360 computers. Additional help will probably be required to actually write and run computer programs."

3. Psychology adapted from Analysis of Behavior: A Program for Self-Instruction by James G. Holland and B. F. Skinner. Copyright held by McGraw-Hill Book Company.

   Principles of classical and operant conditioning are presented. Concepts covered include reflexes, responses, stimuli, conditioning, extinction, reinforcement, generalization, discrimination, superstitious behavior, and reinforcement schedules. The following introduction was adapted from the introduction in the original and was given in the book:

   > "With this book the student should be able to instruct himself in that substantial part of psychology which deals with the analysis of behavior--in particular the explicit prediction and control of the behavior of people. The practical importance of such a science scarcely needs to be pointed out, but understanding and effective use of the science require fairly detailed knowledge. This book is designed to present the basic terms and principles of the science. It is also designed to reveal the inadequacy of popular explanations of behavior and to prepare the student for rapidly expanding extensions into such diverse fields as social behavior and psychopharmacology, space flight and child care, education and psychotherapy."

4. Descriptive Statistics adapted from Descriptive Statistics: A Programmed Textbook by Lassar G. Gotkin and Leo S. Goldstein. Copyright held by John Wiley and Sons, Inc.

   Introductory concepts in descriptive statistics are covered. These include constants, variables, numeric scales, continuous and discrete variables, frequency tables, cumulative frequency, percent, percentiles, mean, mode, median, quartiles, histograms, variance, standard deviation, and Z-scores. The following introduction was given in the book:

   > "With this book the student should be able to instruct himself in introductory descriptive statistics. Statistics is concerned with the analysis of observable facts which are expressed as numbers. These numbers may be test scores, linear measurements, frequencies of events, numbers of people, etc. This book is designed to present the elementary terms and concepts of

> descriptive statistics, and thus to give the student methods of understanding and describing data. The content begins with samples and the origins of data and goes through distributions."

Instructions were given in the front of each book for using the book. A copy of these instructions appears on the following page.

HOW TO USE THE BOOK

The material in this book has been designed in an ordered sequence which requires the student to respond after being presented with a predetermined amount of information. The correct response to each item appears in the lefthand margin of the page immediately following the item. Read each item and when a response is indicated, write your response on a separate piece of paper before looking at the correct response. If necessary, cover the correct response with a slip of paper or cardboard until you are ready to look at it. If your answer is incorrect, mark an "X" beside it. Then continue on to the next item. You will not be penalized for incorrect responses, so be sure to mark each one which you miss. When you have completed this part of the book, count all of the "X's" (incorrect responses) and record this number in the space provided on the cover. This information is necessary to determine how effectively the book teaches.

Writing out the answer is essential. It is also essential to write it before looking at the correct answer. When the student, though well-intentioned, glances ahead without firt putting down an answer of his own, he commits himself to only a vague and poorly formulated guess. This is not effective and in the long run makes the total task more difficult.

It is important to do each item in its proper turn. The sequence has been carefully designed, and occasional apparent repetitions or redundancies are there for good reason. Do not skip. Avoid careless answers. If you begin to make mistakes because you are tired or not looking at the material carefully, take a break.

Conventions

Observe the following conventions:

1. The number of words needed to complete an item is indicated by the number of blanks. Thus "____" indicates a one-word response, whereas "____ ____" indicates a two-word response.

2. There are often several reasonably equivalent responses, and it would be a waste of time to list them all. This is particularly true when the response is nontechnical. Use reasonable judgment in deciding whether your response is synonymous with the printed form. Score it correct if it is.

Before beginning on page 1, be sure to record your class, your name, and the date you are beginning the material. When you finish the material, record that date also, as well as the number of incorrect responses made.

As described in the text, each program was prepared in four versions. These versions are:

1. Every frame is a response frame
2. Every fourth frame is a response frame.
3. Every sixteenth frame is a response frame.
4. Every thirty-second frame is a response frame.

Examples of each of these versions taken from the psychology program are on the following pages.

VERSION 1

	A doctor taps your knee (patellar tendon) with a rubber mallet to test your ________.
reflexes (reflex)	If your reflexes are normal, your leg ________ to the tap on the knee with a slight jerk (the so-called knee jerk).
responds (reacts)	In the knee jerk or patellar-tendon reflex, the kick of the leg is the ________ to the tap on the knee.
response (reaction)	The stimulating object used by the doctor to elicit a knee jerk is a ________.
hammer (mallet)	The stimulus which elicits a knee jerk is the _____ delivered by the so-called stimulus object or hammer.
tap (blow)	In the knee jerk reflex, we call the rubber hammer the stimulus object and the tap or blow the ________.
stimulus	An event is explained when its cause is identified. The "cause" or explanation of the knee jerk is technically the ________ which elicits it.
stimulus (tap on the knee)	Technically speaking, a reflex involves an eliciting stimulus in a process called an elicitation. A stimulus ________ a response.

VERSION 1 (Con't)

elicits	In a reflex, the stimulus and the elicited response occur in a given temporal order; first the stimulus then the __________.
response	A kick of the leg is __________ by a tap on the patellar-tendon.
elicited	The time which elapses between the onset of the stimulus and the onset of the response is called the latency. Thus the time between the tap and the kick is the __________ of the knee-jerk reflex.
latency	The weakest stimulus sufficient to elicit a response marks the threshold of the reflex. A tap on the knee will not elicit a kick if it is below the __________.
threshold	If you __________ when something brushes your eye, the blink is a response.
blink	The fraction of a second which elapses between "brushing the eye" and "blink" is the __________ of the reflex.
latency	In the patellar-tendon reflex, a forceful tap elicits a strong kick; a tap barely above the threshold elicits a weak kick. Magnitude of response depends on the intensity of the __________.
stimulus (tap)	The magnitude of a response corresponds to (is a function of) the __________ of the stimulus which elicits it.

VERSION 1 (Con't)

intensity (magnitude, strength)	A reflex consists of both a stimulus and a response, occurring in that order. The term "reflex" is not synonymous with the single term ___________.
response	When a person is startled by a loud noise, his sudden movement is his response to the noise which has acted as a stimulus. The two together are called a _____________.
reflex	If a sip of a very weak lemonade does not cause salivation, the stimulus is said to be below the __________.
threshold	In the salivary reflex, the stimulus (food) precedes the responses (secretion of saliva) by an interval of time called the _________.
latency	If an actress uses onion juice on her handkerchief to elicit tears during an emotional scene, she must use enough to exceed the _______.
threshold	The greater the concentration of onion juice (stimulus), the ________ the magnitude of the response.
greater (higher-larger)	When speaking technically, instead of saying onion juice "stimulates" tears; we say onion juice ________ tears.
elicits	A child touching a hot surface withdraws his hand quickly. The word "quickly" suggests that the response has a short ________.

VERSION 1 (Con't)

latency	In withdrawing the hand from the hot surface, arm movement is a response which is elicited by a painful ________ to the hand.
stimulus	In the hand-withdrawal reflex, the stimulus must be intense enough to exceed the __________ or no response will occur.
threshold	A light flashed into the eye elicits constriction of the pupil. This sequence is called pupillary __________.
reflex	In the pupillary reflex, a flash of light is said to ____________ response.
elicit	In the pupillary reflex, a very bright flash of light elicits a response of greater ______________ than a weak flash of light.
magnitude (intensity)	A response and its eliciting stimulus comprise a ____________.
reflex	The softest touch on the surface of the eye needed to elicit a blink, marks the __________ of the stimulus.
threshold	In any reflex, there is a stimulus which __________ the response.

VERSION 2

A doctor taps your knee (patellar-tendon) with a rubber mallet to test your reflexes.

If your reflexes are normal, your leg responds to the tap on the knee with a slight jerk (the so-called knee jerk).

In the knee jerk or patellar-tendon reflex, the kick of the leg is the response to the tap on the knee.

The stimulating object used by the doctor to elicit a knee jerk is a ____________.

Hammer
(mallet)

The stimulus which elicits a knee jerk is the tap delivered by the so-called stimulus object or hammer.

In the knee jerk reflex, we call the rubber hammer the stimulus object and the tap or blow the stimulus.

An event is explained when its cause is identified. The "cause" or explanation of the knee jerk is technically the stimulus which elicits it.

Technically speaking, a reflex involves an eliciting stimulus in a process called an elicitation. A stimulus _________ a response.

elicits	In a reflex, the stimulus and the elicited response occur in a given temporal order; first the stimulus then the response.
	A kick of the leg is elicited by a tap on the patellar-tendon.
	The time which elapses between the onset of the stimulus and the onset of the response is called the latency. Thus the time between the tap and the kick is the latency of the knee-jerk reflex.
	The weakest stimulus sufficient to elicit a response marks the threshold of the reflex. A tap on the knee will not elicit a kick if it is below the ________.
threshold	If you blink when something brushes your eye, the blink is a response.
	The fraction of a second which elapses between "brushing the eye" and "blink" is the latency of the reflex.
	In the patellar-tendon reflex, a forceful tap elicits a strong kick; a tap barely above the threshold elicits a weak kick. Magnitude of response depends on the intensity of the stimulus.
	The magnitude of a response corresponds to (is a function of) the ________ of the stimulus which elicits it.

intensity
(magnitude,
strength)

A reflex consists of both a stimulus and a response occurring in that order. The term "reflex" is not synonymous with the single term "response."

When a person is startled by a loud noise, his sudden movement is his response to the noise which has acted as a stimulus. The two together are called a reflex.

If a sip of a very weak lemonade does not cause salivation, the stimulus is said to be below the threshold.

In the salivary reflex, the stimulus (food) precedes the responses (secretion of saliva) by an interval of time called the __________.

latency

If an actress uses onion juice on her handkerchief to elicit tears during an emotional scene, she must use enough to exceed the threshold.

The greater the concentration of onion juice (stimulus), the greater the magnitude of the response.

When speaking technically, instead of saying onion juice "stimulates" tears; we say onion juice "elicits" tears.

A child touching a hot surface withdraws his hand quickly. The word "quickly" suggests that the response has a short __________.

latency

In withdrawing the hand from the hot surface, arm movement is a response which is elicited by a painful stimulus to the hand.

In the hand-withdrawal reflex, the stimulus must be intense enough to exceed the threshold or no response will occur.

A light flashed into the eye elicits constriction of the pupil. This sequence is called pupillary reflex.

In the pupillary reflex, a flash of light is said to ____________ response.

elicit

In the pupillary reflex, a very bright flash of light elicits a response of greater magnitude than a weak flash of light.

A response and its eliciting stimulus comprise a reflex.

The softest touch on the surface of the eye needed to elicit a blink, marks the threshold of the stimulus.

In any reflex, there is a stimulus which ________ any response.

VERSION 3

A doctor taps your knee (patellar-tendon) with a rubber mallet to test your reflexes.

If your reflexes are normal, your leg responds to the tap on the knee with a slight jerk (the so-called knee-jerk).

In the knee-jerk or patellar-tendon reflex, the kick of the leg is the response to the tap on the knee.

The stimulating object used by the doctor to elicit a knee-jerk is a hammer.

The stimulus which elicits a knee-jerk is the tap delivered by the so-called stimulus object or hammer.

In the knee-jerk reflex, we call the rubber hammer the stimulus object and the tap or blow the stimulus.

An event is explained when its cause is identified. The "cause" or explanation of the knee-jerk is technically the stimulus which elicits it.

Technically speaking, a reflex involves an eliciting stimulus in a process called an elicitation. A stimulus elicits a response.

In a reflex, the stimulus and the elicited response occur in a given temporal order; first the stimulus then the response.

A kick of the leg is elicited by a tap on the patellar-tendon.

A time which elapses between the onset of the stimulus and the onset of the response is called the latency. Thus the time between the tap and the kick is the latency of the knee-jerk reflex.

The weakest stimulus sufficient to elicit a response marks the threshold of the reflex. A tap on the knee will not elicit a kick if it is below the threshold.

If you blink when something brushes your eye, the blink is a response.

The fraction of a second which elapses between "brushing the eye" and "blink" is the latency of the reflex.

In the patellar-tendon reflex, a forceful tap elicits a strong kick; a tap barely above the threshold elicits a weak kick. Magnitude of response depends on the intensity of the stimulus.

The magnitude of a response corresponds to (is a function of) the _________ of the stimulus which elicits it.

intensity
(magnitude,
strength)

A reflex consists of both a stimulus and a response, occurring in that order. The term "reflex" is not synonymous with the single term "response."

When a person is startled by a loud noise, his sudden movement is his response to the noise which has acted as a stimulus. The two together are called a reflex.

If a sip of a very weak lemonade does not cause salivation, the stimulus is said to be below the threshold.

In the salivary reflex, the stimulus (food) precedes the responses (secretion of saliva) by an interval of time called the latency.

If an actress uses onion juice on her handkerchief to elicit tears during an emotional scene, she must use enough to exceed the threshold.

The greater the concentration of onion juice (stimulus), the greater the magnitude of the response.

When speaking technically, instead of saying onion juice "stimulates" tears, we say onion juice "elicits" tears.

A child touching a hot surface withdraws his hand quickly. The word "quickly" suggests that the response has a short latency.

In withdrawing the hand from the hot surface, arm movement is a response which is elicited by a painful stimulus to the hand.

In the hand-withdrawal reflex, the stimulus must be intense enough to exceed the threshold or no response will occur.

A light flashed into the eye elicits constriction of the pupil. This sequence is called pupillary reflex.

In the pupillary reflex, a flash of light is said to elicit response.

In the pupillary reflex, a very bright flash of light elicits a response of greater magnitude than a weak flash of light.

A response and its eliciting stimulus comprise a reflex.

The softest touch on the surface of the eye needed to elicit a blink, marks the theshold of the stimulus.

In any reflex, there is a stimulus which ________ the response.

VERSION 4

A doctor taps your knee (patellar-tendon) with a rubber mallet to test your reflexes.

If your reflexes are normal, your leg responds to the tap on the knee with a slight jerk (the so-called knee-jerk).

In the knee jerk or patellar-tendon reflex, the kick of the leg is the response to the tap on the knee.

The stimulating object used by the doctor to elicit a knee-jerk is a hammer.

The stimulus which elicits a knee-jerk is the tap delivered by the so-called stimulus object or hammer.

In the knee-jerk reflex, we call the rubber hammer the stimulus object and the tap or blow the stimulus.

An event is explained when its cause is identified. The "cause" or explanation of the knee-jerk is technically the stimulus which elicits it.

Technically speaking, a reflex involves an eliciting stimulus in a process called an elicitation. A stimulus elicits a response.

In a reflex, the stimulus and the elicited response occur in a given temporal order; first the stimulus then the response.

A kick of the leg is elicited by a tap on the patellar-tendon.

The time which elapses between the onset of the stimulus and the onset of the response is called the latency. Thus the time between the tap and the kick is the latency of the knee-jerk reflex.

The weakest stimulus sufficient to elicit a response marks the threshold of the reflex. A tap on the knee will not elicit a kick if it is below the threshold.

If you blink when something brushes your eye, the blink is a response.

The fraction of a second which elapses between "brushing the eye" and "blink" is the latency of the reflex.

In the patellar-tendon reflex, a forceful tap elicits a strong kick; a tap barely above the threshold elicits a weak kick. Magnitude of response depends on the intensity of the stimulus.

The magnitude of a response corresponds to (is a function of) the intensity of the stimulus which elicits it.

A reflex consists of both a stimulus and a response occurring in that order. The term "reflex" is not synonymous with the single term "response."

When a person is startled by a loud noise, his sudden movement is his response to the noise which has acted as a stimulus. The two together are called a reflex.

If a sip of a very weak lemonade does not cause salivation, the stimulus is said to be below the threshold.

In the salivary reflex, the stimulus (food) precedes the responses (secretion of saliva) by an interval of time called the latency.

If an actress uses onion juice on her handkerchief to elicit tears during an emotional scene, she must use enough to exceed the threshold.

The greater the concentration of onion juice (stimulus), the greater the magnitude of the response.

When speaking technically, instead of saying onion juice "stimulates" tears; we say onion juice "elicits" tears.

A child touching a hot surface withdraws his hand quickly. The word "quickly" suggests that the response has a short latency.

In withdrawing the hand from the hot surface, arm movement is a response which is elicited by a painful stimulus to the hand.

In the hand-withdrawal reflex, the stimulus must be intense enough to exceed the threshold or no response will occur.

A light flashed into the eye elicits a constriction of the pupil. This sequence is called pupillary reflex.

In the pupillary reflex, a flash of light is said to elicit a response.

In the pupillary reflex, a very bright flash of light elicits a response of greater magnitude than a weak flash of light.

A response and its eliciting stimulus comprise a reflex.

The softest touch on the surface of the eye needed to elicit a blink, marks the threshold of the stimulus.

In any reflex, there is a stimulus which __________ the response.

Appendix C

Instruments Developed for the Study

INFORMATION SHEET

DATE: ____________

NAME ______________________________ STUDENT NO. ____________

ADCOM ROOM ______________ ADCOM TEACHER ______________

FOR THE FOLLOWING ITEMS PLEASE CIRCLE THE CORRECT ANSWER:

CURRENT GRADE LEVEL: 9 10 11 12

DATE OF BIRTH:

	1	2	3	4	5	6	7	8	9	10	11	12
MONTH:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

YEAR: 1950 1951 1952 1953 1954 1955 1956

SEX: 1.M 2.F

NUMBER OF YEARS PREVIOUSLY AT NOVA SCHOOLS:

0 1 2 3 4 5

LIST ALL THE COURSES FOR WHICH YOU ARE CURRENTLY ENROLLED:

1.______________ 5.______________

2.______________ 6.______________

3.______________ 7.______________

4.______________ 8.______________

Please do not write in this space

gr 1
no 2
gd 6
mo 8
yr 11
sx 12
ny 13
nc 14
c 16 18
c 20 22
c 24 26
c 28 30

RDG
c 33
v 35
t 37
r 40

i 43

isa 45
isf 47
isp 49
iss 51

cs 53

Form 4A;Project 7-D-072;8/68

NON-PARTICIPATION RESPONSE SHEET

This sheet is to be completed by those students who do not plan to participate in the Nova R project.

NAME________________________________ STUDENT NUMBER__________

Please answer the questions below and sign your name at the bottom.

1. Why are you not going to participate in the project?__________

____

____

____

____

____

2. Would you participate if the project was conducted later in the year?

   ____Yes ____No

3. Would you participate if the project was different in some way?

   ____Yes ____No

   If you answered "Yes," how would you want the project to be different?

____

____

____

____

4. Do you think that research should be conducted in Nova High School?

   ____Yes ____No

5. Do you have any additional comments?____________________

____

____

____

Date____________________ Signature____________________

HIGH SCHOOL CURRICULUM SURVEY

Form A

PLEASE DO NOT WRITE ON THIS BOOKLET

INSTRUCTIONS:

A number of pairs of courses which are frequently offered in high schools are listed on the following pages. Assume that you have one elective and must choose between the two courses listed in each pair. Select the course in each pair which you THINK you would prefer to take.

Sometimes you may like both courses or dislike both courses in a pair. However, you are to mark only ONE. Remember to think of these courses as possible electives that you must choose between.

Occassionally, you may not be sure what the course is about; however, pick it or the other course on the basis of what you think the course is about.

This is NOT a test. There are no correct answers. Select each course according to what you think.

Please select ONE course for EVERY pair. Indicate your selections on the answer sheet provided. Fill-in the space on the answer sheet corresponding to the course which you have selected. A special pencil is NOT required. You may use any pencil or a pen. If you wish to change an answer, either erase the incorrect answer or draw a large X through it.

You may begin now. There is no time limit, but please work as rapidly as you can.

PLEASE DO NOT WRITE ON THIS BOOKLET

Prepared by John M. Flynn, Nova University, 1968

1. a. Practical Logic
b. Digital Computer Principles

2. a. Aerodynamics
b. Digital Computer Principles

3. a. Psychology of Learning
b. Descriptive Astronomy

4. a. English Composition
b. Computer Programming (FORTRAN)

5. a. General Psychology
b. General Chemistry

6. a. Psychology of Learning
b. Practical Logic

7. a. Computer Programming (FORTRAN)
b. General Physics

8. a. English Composition
b. Algebra

9. a. Basic Economics
b. German (language)

10. a. Descriptive Statistics
b. Digital Computer Principles

11. a. General Physics
b. Organic Chemistry

12. a. Aerodynamics
b. Computer Programming (FORTRAN)

13. a. Algebra
b. Bookkeeping

14. a. English Composition
b. German (language)

15. a. General Psychology
b. Basic Economics

16. a. Descriptive Statistics
b. Practical Logic

17. a. Oriental Philosophy
b. Computer Programming (FORTRAN)

18. a. Algebra
b. Aerodynamics

19. a. German (language)
b. Descriptive Astronomy

20. a. Basic Economics
b. Bookkeeping

21. a. Psychology of Learning
b. English Composition

22. a. General Psychology
b. Computer Programming (FORTRAN)

23. a. Algebra
b. Descriptive Statistics

24. a. Organic Chemistry
b. German (language)

25. a. Oriental Philosophy
b. General Chemistry

26. a. General Physics
b. Psychology of Learning

27. a. English Composition
b. Descriptive Astronomy

28. a. Computer Programming (FORTRAN)
b. Basic Economics

29. a. Algebra
b. German (language)

30. a. Oriental Philosophy
b. Bookkeeping

31. a. Practical Logic
b. Plane Geometry

32. a. Psychology of Learning
b. General Psychology

33. a. General Physics
b. English Composition

34. a. Descriptive Astronomy
b. Aerodynamics

35. a. Aerodynamics
b. General Chemistry

36. a. Computer Programming (FORTRAN)
b. Bookkeeping

37. a. Electronics
b. Social Psychology

38. a. Basic Economics
b. Organic Chemistry

39. a. Oriental Philosophy
b. Psychology of Learning

40. a. English Composition
b. Aerodynamics

41. a. General Chemistry
b. German (language)

42. a. Descriptive Astronomy
b. Basic Economics

43. a. Basic Economics
b. Oriental Philosophy

44. a. Algebra
b. Physical Optics

45. a. Computer Programming (FORTRAN)
b. General Chemistry

46. a. Aerodynamics
b. Psychology of Learning

47. a. Bookkeeping
b. Descriptive Statistics

48. a. Digital Computer Principles
b. Oriental Philosophy

49. a. General Physics
b. Algebra

50. a. German (language)
b. Plane Geometry

51. a. Descriptive Astronomy
b. Computer Programming (FORTRAN)

52. a. General Chemistry
b. Digital Computer Principles

53. a. Aerodynamics
b. Basic Economics

54. a. Descriptive Statistics
b. General Physics

55. a. Bookkeeping
b. German (language)

56. a. Psychology of Learning
b. Computer Programming (FORTRAN)

57. a. English Composition
b. Practical Logic

58. a. Basic Economics
b. General Chemistry

59. a. Digital Computer Principles
b. General Psychology

60. a. Descriptive Astronomy
b. Descriptive Statistics

61. a. Aerodynamics
b. Bookkeeping

62. a. Practical Logic
b. Algebra

63. a. General Chemistry
b. Plane Geometry

64. a. Driver Training
b. Accounting

65. a. Computer Programming (FORTRAN)
b. Digital Computer Principles

66. a. General Physics
b. General Psychology

67. a. Aerodynamics
b. German (language

68. a. Descriptive Statistics
b. General Chemistry

69. a. Bookkeeping
b. Practical Logic

70. a. Algebra
b. Digital Computer Principles

71. a.Descriptive Astronomy
b. Bookkeeping

72. a. Aerodynamics
b. Practical Logic

73. a. American History
b. German (language)

74. a. General Chemistry
b. Psychology of Learning

75. a. Algebra
b. Oriental Philosophy

76. a. Bookkeeping
b. General Physics

77. a. General Psychology
b. English Composition

78. a. Computer Programming (FORTRAN)
b. Practical Logic

79. a. Aerodynamics
b. General Chemistry

80. a. Algebra
b. Descriptive Astronomy

81. a. Descriptive Statistics
b. Psychology of Learning

82. a. English Composition
b. Digital Computer Principles

83. a. General Psychology
b. Practical Logic

84. a. Bookkeeping
b. General Chemistry

85. a. Oriental Philosophy
b. General Physics

86. a. Basic Economics
b. Psychology of Learning

87. a. Computer Programming (FORTRAN)
b. Descriptive Statistics

88. a. Bookkeeping
b. Organic Chemistry

89. a. Descriptive Astronomy
b. Practical Logic

90. a. General Psychology
b. German (language)

91. a. General Chemistry
b. English Composition

92. a. Algebra
b. Computer Programming (FORTRAN)

93. a. General Psychology
b. Aerodynamics

94. a. Oriental Philosophy
b. Practical Logic

95. a. Basic Economics
b. General Physics

96. a. Social Psychology
b. English Composition

97. a. Algebra
b. General Chemistry

98. a. Aerodynamics
b. Business Mathematics

99. a. Oriental Philosophy
b. Descriptive Statistics

100. a. Basic Economics
b. Accounting

101. a. General Chemistry
b. Practical Logic

102. a. Psychology of Learning
b. German (language)

103. a. Bookkeeping
b. Digital Computer Principles

104. a. General Psychology
b. Descriptive Statistics

105. a. Aerodynamics
b. General Physics

106. a. Basic Economics
b. English Composition

107. a. Business Mathematics
b. Practical Logic

108. a. Organic Chemistry
b. Digital computer Principles

109. a. General Psychology
b. Descriptive Astronomy

110. a. Bookkeeping
b. Electronics

111. a. General Chemistry
b. General Physics

112. a. Basic Economics
b. Descriptive Statistics

113. a. German (language)
b. Digital Computer Principles

114. a. Social Psychology
b. Practical Logic

115. a. General Psychology
b. Oriental Philosophy

116. a. Psychology of Learning
b. Algebra

117. a. Basic Economics
b. Physical Optics

118. a. Digital computer Principles
b. Descriptive Astronomy

119. a. German (language)
b. General Physics

120. a. Descriptive Statistics
b. English Composition

121. a. Algebra
b. General Psychology

122. a. Oriental Philosophy
b. Aerodynamics

123. a. Descriptive Astronomy
b. General Chemistry

124. a. German (language)
b. Practical Logic

125. a. Algebra
b. Basic Economics

126. a. Oriental Philosophy
b. English Composition

127. a. General Physics
b. Digital Computer Principles

128. a. Oriental Philosophy
b. Descriptive Astronomy

129. a. German (language)
b. Computer Programming (FORTRAN)

130. a. Practical Logic
b. Basic Economics

131. a. Bookkeeping
b. Psychology of Learning

132. a. Descriptive Astronomy
b. General Physics

133. a. Aerodynamics
b. Descriptive Statistics

134. a. Oriental Philosophy
b. German (language)

135. a. Digital Computer Principles
b. Basic Economics

136. a. General Psychology
b. Bookkeeping

137. a. Bookkeeping
b. English Composition

138. a. General Physics
b. Practical Logic

139. a. Descriptive Statistics
b. German (language)

140. a. Psychology of Learning
b. Digital Computer Principles

ANSWER SHEET FOR HIGH SCHOOL CURRICULUM SURVEY

NAME________________ STUDENT NO.____________ DATE________ BOOKLET NO.________

	a	b		a	b		a	b		a	b		a	b
1.	☐	☐	29.	☐	☐	57.	☐	☐	85.	☐	☐	113.	☐	☐
2.	☐	☐	30.	☐	☐	58.	☐	☐	86.	☐	☐	114.	☐	☐
3.	☐	☐	31.	☐	☐	59.	☐	☐	87.	☐	☐	115.	☐	☐
4.	☐	☐	32.	☐	☐	60.	☐	☐	88.	☐	☐	116.	☐	☐
5.	☐	☐	33.	☐	☐	61.	☐	☐	89.	☐	☐	117.	☐	☐
6.	☐	☐	34.	☐	☐	62.	☐	☐	90.	☐	☐	118.	☐	☐
7.	☐	☐	35.	☐	☐	63.	☐	☐	91.	☐	☐	119.	☐	☐
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9.	☐	☐	37.	☐	☐	65.	☐	☐	93.	☐	☐	121.	☐	☐
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11.	☐	☐	39.	☐	☐	67.	☐	☐	95.	☐	☐	123.	☐	☐
12.	☐	☐	40.	☐	☐	68.	☐	☐	96.	☐	☐	124.	☐	☐
13.	☐	☐	41.	☐	☐	69.	☐	☐	97.	☐	☐	125.	☐	☐
14.	☐	☐	42.	☐	☐	70.	☐	☐	98.	☐	☐	126.	☐	☐
15.	☐	☐	43.	☐	☐	71.	☐	☐	99.	☐	☐	127.	☐	☐
16.	☐	☐	44.	☐	☐	72.	☐	☐	100.	☐	☐	128.	☐	☐
17.	☐	☐	45.	☐	☐	73.	☐	☐	101.	☐	☐	129.	☐	☐
18.	☐	☐	46.	☐	☐	74.	☐	☐	102.	☐	☐	130.	☐	☐
19.	☐	☐	47.	☐	☐	75.	☐	☐	103.	☐	☐	131.	☐	☐
20.	☐	☐	48.	☐	☐	76.	☐	☐	104.	☐	☐	132.	☐	☐
21.	☐	☐	49.	☐	☐	77.	☐	☐	105.	☐	☐	133.	☐	☐
22.	☐	☐	50.	☐	☐	78.	☐	☐	106.	☐	☐	134.	☐	☐
23.	☐	☐	51.	☐	☐	79.	☐	☐	107.	☐	☐	135.	☐	☐
24.	☐	☐	52.	☐	☐	80.	☐	☐	108.	☐	☐	136.	☐	☐
25.	☐	☐	53.	☐	☐	81.	☐	☐	109.	☐	☐	137.	☐	☐
26.	☐	☐	54.	☐	☐	82.	☐	☐	110.	☐	☐	138.	☐	☐
27.	☐	☐	55.	☐	☐	83.	☐	☐	111.	☐	☐	139.	☐	☐
28.	☐	☐	56.	☐	☐	84.	☐	☐	112.	☐	☐	140.	☐	☐

Name ______________________

Student Number ____________

ASTRONOMY QUESTIONNAIRE

Please answer each of the following questions by circling either "yes" or "no" as they apply. Answer every question as truthfully as possible.

Yes No 1. Have you ever been taught in school anything about astronomy?

Yes No 2. Have you ever read a book about astronomy?

Yes No 3. Have you ever read a magazine article about astronomy?

Yes No 4. Is anyone you know an astronomer?

Yes No 5. Have you ever visited an astronomy observatory?

Yes No 6. Have you ever talked to an astronomer about astronomy?

Yes No 7. Have you ever watched an astronomer work?

Yes No 8. Is your father or mother an astronomer?

Yes No 9. Do you ever talk about astronomy at home with members of your family?

Yes No 10. Do you know what an astronomer does?

Name ______________________

Student Number ______________________

COMPUTER PROGRAMMING

Please answer each of the following questions by circling either "yes" or "no" as they apply. Answer every question as truthfully as possible.

Yes No 1. Have you ever been taught in school anything about computer programming?

Yes No 2. Have you ever read a book about computer programming?

Yes No 3. Have you ever read a magazine article about computer programming?

Yes No 4. Is anyone you know a computer programmer?

Yes No 5. Have you ever visited a computing installation?

Yes No 6. Have you ever talked to a computer programmer about computer programming?

Yes No 7. Have you ever watched a computer programmer work?

Yes No 8. If your father or mother a computer programmer

Yes No 9. Do you ever talk about computer programming at home with members of your family?

Yes No 10. Do you know what a computer programmer does?

Name ______________________

Student Number ______________

PSYCHOLOGY QUESTIONNAIRE

Please answer each of the following questions by circling either "yes" of "no" as they apply. Answer every question as truthfully as possible.

Yes No 1. Have you ever been taught in school anything about psychology?

Yes No 2. Have you ever read a book about psychology?

Yes No 3. Have you ever read a magazine article about psychology?

Yes No 4. Is anyone you know a psychologist?

Yes No 5. Have you ever visited a psychological laboratory?

Yes No 6. Have you ever talked to a psychologist about psychology?

Yes No 7. Have you ever watched a psychologist work?

Yes No 8. Is your father or mother a psychologist?

Yes No 9. Do you ever talk about psychology at home with members of your family?

Yes No 10. Do you know what a psychologist does?

Name ______________________

Student Number ____________

STATISTICS QUESTIONNAIRE

Please answer each of the following questions by circling either "yes" or "no" as they apply. Answer every question as truthfully as possible.

Yes No 1. Have you ever been taught in school anything about statistics?

Yes No 2. Have you ever read a book about statistics?

Yes No 3. Have you ever read a magazine article about statistics?

Yes No 4. Is anyone you know a statistician?

Yes No 5. Have you ever visited a statistical laboratory?

Yes No 6. Have you ever talked to a statistician about statistics?

Yes No 7. Have you ever watched a statistician work?

Yes No 8. Is your father or mother a statistician?

Yes No 9. Do you ever talk about statistics at home with members of your family?

Yes No 10. Do you know what a statistician does?

Booklet Number 22

ASTRONOMY ACHIEVEMENT TEST

FORM A

- DO not write on this test booklet -

- Write only on the answer sheet provided -

INSTRUCTIONS:

1. This is a multiple choice test in astronomy. There is no time limit for this test. Most students will finish in 45 to 60 minutes.

2. Complete the information requested on the answer sheet.

3. Record your answers by filling in the corresponding space on the answer sheet. You may use any pencil.

4. If you have any questions about how to take this examination, ask the monitor.

- DO NOT WRITE ON THIS TEST BOOKLET -

Prepared by Dr. J. M. Flynn, Nova University, 1968

1. The force of attraction between a planet and any object on its surface is called the planet's surface:

   1) inertia
   2) gravity
   3) mass
   4) attraction

2. An observer on Earth would see:

   1) the Sun rise before Venus.
   2) Venus rise before the Sun.
   3) the Sun and Venus rise at the same time.
   4) none of the above.

3. The Moon's period of rotation:

   1) is half as long as its period of revolution.
   2) equals its period of revolution.
   3) is twice as long as its period of revolution.
   4) is three times as long as its period of revolution.

4. An observer on Mars could determine that the Earth's period of revolution is:

   1) about twice as long as that of Mars.
   2) about half as long as that of Mars.
   3) about equal to that of Mars.
   4) about three times as long as that of Mars.

5. If you weigh 100 pounds on Earth you would weigh:

   1) 5 pounds on Mars
   2) 40 pounds on Mars
   3) 100 pounds on Mars
   4) 200 pounds on Mars

6. Which of the following statements best describes the center of the Sun?

   1) It is a gaseous state, its pressure is very great and its temperature is exceedingly high.
   2) It is a solid state, the pressure is very great and the temperature is relatively low.
   3) It is a gaseous state, the pressure is very great and the temperature is low.
   4) It is a solid state, the pressure is low and the temperature is exceedingly great.

7. The diameter of the Sun is about:

   1) 8,000 miles
   2) 240,000 miles
   3) 865,000 miles
   4) 93,000,000 miles

3

8. Looking down at the Earth from above the North Pole, the direction in which the Earth rotates and revolves is:

   1) clockwise
   2) East to West
   3) North to South
   4) counterclockwise

9. When the Moon passes between us and a star other than the Sun we call this:

   1) a transit
   2) an eclipse
   3) an elipse
   4) an occulation

10. The length of time required for the Earth to orbit once around the Sun is called the Earth's period of:

    1) rotation
    2) revolution
    3) inclination
    4) orbicularity

11. On a given day the rays of sunlight at sunset must travel through:

    1) the same amount of the Earth's atmosphere to reach us at noon.
    2) more of the Earth's atmosphere to reach us than at noon.
    3) the same amount of atmosphere to reach us as at noon.
    4) none of the above are correct.

12. In comparison to the surface gravity on the Earth, the surface gravity on Mars is:

    1) about the same.
    2) lower.
    3) greater.
    4) Scientists have been unable to determine anything about the surface gravity on Mars.

13. Higher forms of plant life as we know them on Earth probably:

    1) would have enough oxygen and water to survive on Mars.
    2) would probably have enough oxygen, but not enough water to survive on Mars.
    3) would have enough water, but not enough oxygen to survive on Mars.
    4) would have neither enough oxygen or water to survive on Mars.

14. The inner planets are:

    1) Earth and Mercury
    2) Venus and Mars
    3) Venus and Earth
    4) Mercury and Venus

15. The name of the surface of the Sun is:

1) chromosphere
2) photosphere
3) corona
4) none of the above

16. When the Earth is between the Sun and the Moon, an observer on the Moon would see the Earth as:

1) a new Earth
2) a full Earth
3) a crescent Earth
4) a half Earth

17. Days on Mars are:

1) longer than those on Earth.
2) shorter than those on Earth.
3) exactly the same as those on Earth.
4) since Mars does not rotate, there are no days on Mars.

18. The Earth's orbit lies between the orbits of:

1) Mercury and Venus
2) Venus and Mars
3) Mars and Jupiter
4) none of the above

19. Which one of the following planets is the smallest?

1) Venus
2) Earth
3) Mercury
4) Mars

20. The angle between the Earth's axis and the perpendicular to the plane of its orbit i :

1) 72-1/2 degrees
2) 7-1/2 degrees
3) 23-1/2 degrees
4) none of the above

21. The plane of the Moon's orbit is:

1) above the Earth's plane of revolution.
2) below the Earth's plane of revolution.
3) equal with the Earth's plane of revolution.
4) sometimes above and sometimes below the Earth's plane of revolution.

22. Which of the following statements about Mercury is correct?

1) The bright side of Mercury is too hot to sustain life.
2) Both the dark and the bright sides of Mercury are temperate enough to support life.
3) The dark side of Mercury is too cold for life to exist.
4) Statements 1 and 3 are both correct.

23. Consider the Winter season in both the Northern and Southern Hemispheres; which of the following statements is correct?

1) The Earth is farther from the Sun during Winter in the Northern Hemispher than during Winter in the Southern Hemisphere.
2) The Earth is closer to the Sun during Winter in the Northern Hemisphere than during Winter in the Southern Hemisphere.
3) The Earth is the same distance from the Sun during the Winters in both Hemispheres.
4) None of the above are correct.

24. When the Earth is closest to the Sun, it is:

1) Summer in the Northern Hemisphere and Winter in the Southern Hemisphere.
2) Summer in both the Northern and Southern Hemispheres.
3) Winter in both the Northern and Southern Hemispheres.
4) Winter in the Northern Hemisphere and Summer in the Southern Hemisphere.

25. As a magnet becomes closer to a piece of iron, the effect of the magnet on the iro

1) decreases as the distance decreases.
2) increases in amount equal to the amount the distance decreases.
3) increases in amount greater than the distance decreases.
4) increases in amount less than the distance decreases.

26. On which of the following heavenly bodies would a person be least likely to hear a hammer striking a piece of steel?

1) Mercury and Mars
2) the Moon and Mars
3) Mercury and the Moon
4) the Moon, Mercury and Mars

27. Which of the following statements is most correct?

1) The Earth maintains a constant distance from the Sun which contributes to our seasons.
2) The Earth varies in its distance from the Sun which directly causes our seasons.
3) The Earth maintains a constant distance from the Sun and this does not contribute to our seasons.
4) The distance from the Earth to the Sun varies but this doe not cause our seasons.

28. The area of the Earth which usually receives the most slanting rays from the Sun is:

1) the Equator
2) the Northern Hemisphere
3) the poles
4) the Southern Hemisphere

29. Which of the following planets has the highest orbital velocity?

1) Mercury
2) Venus
3) Earth
4) Mars

30. The third smallest planet is:

1) Mercury
2) Venus
3) Earth
4) Mars

31. The amount of light received by a planet and then reflected by the planet is called the planet's:

1) albeit
2) albescent
3) albite
4) albedo

32. You weigh three times as much on Earth as you would on,

1) the Moon
2) Venus
3) Mars
4) Mercury

33. The approximate distance from the Earth to the Moon is about:

1) 40,000 miles.
2) 120,000 miles
3) 240,000 miles
4) 480,000 miles

34. Which of the following methods have been used to measure the distance from the Earth to the Moon?

1) The electronic method of radar.
2) The mathematical method of triangulation.
3) The geometric method of inclination.
4) 1 and 2 above but not 3.

35. If the Earth did not have an atmosphere, which of the following conditions would be present?

1) The Earth will undergo extremes of heat and cold.
2) The Earth will have no water or water vapor.
3) People and animals will not be able to breath.
4) All of the above conditions would be present.

36. When the Moon is between the Sun and the Earth, an observer on Earth sees the Moon as a:

1) new moon
2) full moon
3) half moon
4) crescent moon

37. Which of the following planets has (have) only a single natural satellite?

1) both Mars and Earth.
2) Mars
3) Venus
4) Earth

38. Which of the following planets do we observe from Earth to have transits?

1) Mercury and Venus
2) Mercury and Mars
3) Mars and Venus
4) Mercury, Venus and Mars

39. The Moon's rotation with respect to the Earth is most similar to that of the planet:

1) Mercury with respect to the Sun
2) Venus with respect to the Sun
3) the Earth with respect to the Sun
4) Mars with respect to the Sun

40. From Earth, Mars appears as:

1) almost full all the time
2) almost dark all the time
3) partially lighted and partially dark all the time
4) in various phases ranging from dark to completely lightened

41. An observer on Venus would:

1) see the Earth go through phases from full through crescent.
2) always see Earth as full.
3) always see Earth as dark.
4) see Earth go from dark to half full and then back to dark.

42. The Earth's atmosphere extends several hundred miles into space; however, about 75% of the atmosphere is concentrated in the first:

1) 2 miles
2) 4 miles
3) 7 miles
4) 25 miles

43. The Earth's inertia tends to make the Earth move in a straight line at:

1) 4 miles per second.
2) 12 miles per second.
3) 18 miles per second.
4) 25 miles per second.

44. At noon during the Summer, the Sun is:

1) lower in the sky than in the Winter.
2) the same height in the sky as in the Winter.
3) higher in the sky than in the Winter.
4) None of the above are correct since the height of the Sun depends only on the location of the observer.

45. Which of the following statements is correct for an observer on Earth?

1) Venus, Mars and the Moon go through phases
2) Mars, Mercury and Venus go through phases
3) Mercury, Venus and the Moon go through phases
4) Venus, the Moon and Mars go through phases

46. Which of the following numbers indicates how many times greater than the Earth's diameter is than the Moon's diameter.

1) 2 times
2) 4 times
3) 6 times
4) 8 times

47. The surface gravity and the velocity of escape of a planet depend upon a planet's:

1) size
2) mass
3) size and mass
4) none of the above

48. If an object is 5000 miles above the surface of the Earth it is:

1) 5000 miles from the Earth's center of gravity.
2) 9000 miles from the Earth's center of gravity.
3) 13,000 miles from the Earth's center of gravity.
3) 15,000 miles from the Earth's center of gravity.

49. The amount of time required for a radar pulse to travel from the Earth to the Moon i

1) 1/2 second
2) 2-1/2 seconds
3) 7-1/2 seconds
4) 11 seconds

50. If an object such as a brick was weighed at the Earth's surface and again at a position 6000 miles above the Earth's surface, it will:

1) weigh the same at both positions.
2) weigh less at the Earth's surface than at 6000 miles above the Earth's surf
3) weigh more at the Earth's surface than at 6000 miles above the Earth's surf
4) None of the above are correct.

51. The atmospheric pressure at sea level is about:

1) 2 pounds per square inch
2. 7.6 pounds per square inch
3) 14.7 pounds per square inch
4) 28.9 pounds per square inch

52. Which of the following planets has visable polar ice caps like the Earth?

1) Mars
2) Mercury
3) Venus
4) Both Venus and Mars

53. If a planet is to retain its atmosphere, its velocity of escape must be:

1) slower than the velocity of the planet's gas molecules.
2) the same as the velocity of the planet's gas molecules.
3) faster than the velocity of the planet's gas molecules.
4) either the same as or slower than the velocity of the planet's gas molecul

54. When it is Winter in the Northern Hemisphere, a man standing within the Arctic Circle experiences:

1) darkness at noon and at midnight
2) daylight at midnight and darkness at noon
3) daylight at noon and at midnight
4) daylight at noon and darkness at midnight

55. Which of the following statements best describes Mercury's atmosphere?

1) It is very thick and rich in oxygen.
2) It is very thick but there is very little oxygen.
3) It is very thin with practically no oxygen.
4) It is very thin, but there is lots of oxygen.

56. A planet whose orbital velocity is much slower than that of the Earth's is:

    1) closer to the Sun than the Earth.
    2) further from the Sun than the Earth.
    3) the same distance from the Sun as the Earth.
    4) non-existent because all planets must travel as fast as or faster than the Ear

57. When the Moon passes across the face of the Sun we call it:

    1) a transit
    2) an inner planet
    3) an occulation
    4) an eclipse

58. The effect of a planet's inertia and of the Sun's gravitational attraction on the planet causes the planet to:

    1) rotate about its axis.
    2) to follow an eliptical orbit around the Sun.
    3) to follow a parabolic orbit around the Sun.
    4) to wobble on its axis.

59. To calculate the density of a body, we need to know:

    1) only the amount of its surface gravity.
    2) its mass and its surface gravity.
    3) its volume and its diameter.
    4) its mass and its volume.

60. On which of the following heavenly bodies do scientists consider the existence of plant life to be most likely?

    1) Mercury
    2) Venus
    3) the Moon
    4) Mars

61. Which of the following statements, if any, is correct?

    1) The Earth moves fastest when it is closest to the Sun.
    2) The Earth moves fastest when it is furthest from the Sun.
    3) The Earth moves at the same speed regardless of its distance from the Sun.
    4) None of the above statements are correct.

62. For a given unit of area on the Earth

    1) the Sun's direct rays provide more heat than do the slanting rays.
    2) the slanting rays of the Sun provide more heat than do the direct rays.
    3) the direct and slanting rays provide the same amount of heat.
    4) None of the above are correct.

63. We can listen to each other speak on Earth primarily because:

1) the Earth's surface transmits the sound of our voices.
2) the Earth's atmosphere transmits the sound of our voices.
3) sound waves can be transmitted with or without the presence of matter.
4) Of all of the above.

64. The planet Venus travels:

1) at the same rate of speed as the Earth.
2) slower than the Earth.
3) faster than the Earth.
4) astronomers have not been able to determine the relative speed of Venus compared to the Earth.

19

Booklet Number ________________

COMPUTER PROGRAMMING ACHIEVEMENT TEST

FORM A

- Do not write on this test booklet -

- Write only on the answer sheet provided -

INSTRUCTIONS:

1. This is a multiple choice test in computer programming. There is no time limit for this test. Most students will finish in 45 to 60 minutes.

2. Complete the information requested on the answer sheet.

3. Record your answers by filling in the corresponding space on the answer sheet. You may use any pencil.

4. If you have any questions about how to take this examination, ask the monitor.

- DO NOT WRITE ON THIS TEST BOOKLET -

Prepared by Dr. J. M. Flynn, Nova University, 1968

1. Which of the following statements is not a control statement in the FORTRAN language?

   1) the IF statement
   2) the GO TO statement
   3) the CONTINUE statement
   4) the WRITE statement

2. To determine if a computed quantity is less than, equal to, or greater than another quantity, the programer can write an IF statement where the expression in the statement is:

   1) a sum of the two quantities
   2) a difference of the two quantities
   3) the computed quantity alone
   4) none of the above

3. If A = +8 which of the following statements describes what will happen when the computer executes the statement 3 IF(A)1,5,3 ?

   1) control would pass next to statement number 5
   2) control would pass next to statement number 1
   3) control would pass next to statement number 3
   4) control would pass next to whatever statement comes next regardless of its number

4. Which of the following statements best describes the variables which may be used in WRITE statements?

   1) they may be a fixed mode with or without subscripts
   2) they may be of either mode but must not have subscripts
   3) they must be floating-point mode and cannot have subscripts
   4) they can be of either mode and may have subscripts

5. Consider the following program segment:

```
DO 10 I = 1,10
DO 10 J = 1,10
IF(A(I) = B(J) 10,20,10
```

   What will be the values of I and J the seventh time the IF statement is executed?

   1) I = 7 J = 1
   2) I = 7 J = 7
   3) I = 1 J = 7
   4) I = 1 J = 1

6. The conversion code for FORMAT statements which is used for spacing portions of the OUTPUT on a given line is the:

   1) H conversion
   2) I conversion
   3) P conversion
   4) X conversion

7. An IF statement can control the progress of a loop in a program by:

   1) testing a counter computed in the loop
   2) testing some computed quantity other than a counter in the loop
   3) by presetting a specific number of executions of the loop
   4) both 1 and 2 are correct but not 3

8. The FORTRAN constants in the expression [illegible] = 4.28*C**2 are:

   1) C
   2) 4.28 only
   3) 2 only
   4) both 2 and 4.28

9. The statement Y = X**0.5 shows:

   1) the use of the exponent 0.5 to compute the square root
   2) the multiplication of X by .05
   3) the use of the exponent 0.5 to compute the fifth root of X
   4) the use of the exponent 0.5 to compute the fifth power of X

10. Which of the following statements is correct?

   1) statement numbers must be chosen sequentially and cannot be larger in size than five digits.
   2) statement numbers can be chosen in arbitrary fashion but they must not be larger than three digits
   3) statement numbers must be chosen sequentially and they cannot be larger than three digits
   4) statement numbers can be chosen in arbitrary fashion but they must not be larger than five digits

11. Which of the following statements is correct?

   1) the STOP statement causes the computer to completely halt and the PAUSE statement cause it to halt for only a minute
   2) both the STOP and PAUSE statements cause the computer to completely halt but the PAUSE statement will permit it to be started up again by pushing a button
   3) neither the STOP nor the PAUSE statement cause the computer to halt but is used only by the programmer to stop a particular operation
   4) none of the above statements are correct

12. Which of the following is a true restriction on the index variable of a DO loop?
   1) you cannot change its value by using it on the left of an arithmetic formula statement
   2) you cannot use it as a term in an expression
   3) you cannot use it anywhere else in the program other than the DO loop
   4) all of the above are true restrictions on the index variable

13. By adding a letter X in the appropriate place the statement ANSWER = INPUT*OUTPUT+WEIGHT can be made to contain only floating-point quantities. Before which of the words listed below should the X be placed?

1) ANSWER
2) INPUT
3) OUTPUT
4) WEIGHT

14. Which one, if any, of the following variable names are fixed-point variables?

1) BSTR
2) HERT
3) MOST
4) none of the above names are fixed-point variables

15. Given a DO-loop such as the following: DO 30 J=1,75
On the fifth pass through the DO-loop the value of J is equal to:

1) 5
2) 75
3) 5
4) 50

16. Which of the following situations is specified by the statement FORMAT(15,F15.4)?

1) 2 fixed-point numbers will be read
2) 2 floating-point numbers will be read
3) the first number read will be floating-point; the second number read will be fixed-point
4) the first number read will be fixed-point; the second number read will be floating-point

17. The FORTRAN statement which controls a loop by setting a counter and testing its value is the:

1) IF statement
2) GO TO statement
3) DO statement
4) READ statement

18. Which one of the following statements is illegal as the terminal statement in a DO loop?

1) GO TO 75
2) CONTINUE
3) READ (1,1) X,Y
4) Y=Z+2*X

19. The statement READ(1,2)I,J,K,A(I),C(K) will cause how many values to be read?

    1) 1
    2) 5
    3) 3
    4) 7

20. A FORTRAN expression representing the algebraic expression $4.7\ x^2 - 2.9\ x - 0.7$ is:

    1) 4.7 X**2-2.9X-0.7
    2) 4.7**X*2-2.9**X-0.7
    3) 4.7*X**2-2.9*X-0.7
    4) none of the above FORTRAN expressions correctly represent the algebraic expression

21. The format for placing a FORTRAN statement on a card is as follows:

    1) the statement number is punched in columns 1 thru 6 of the card and the statement is punched anywhere in columns 7 through 80
    2) the statement number is punched in columns 1 thru 5 of the card and the statement is punched anywhere in columns 6 through 72
    3) the statement number is punched in columns 1 thru 6 of the card and the statement is punched anywhere in columns 7 through 72
    4) the statement number is punched in columns 1 thru 6 of the card and the statement is punched anywhere in columns 7 through 72

22. Both alphabetic and numeric characters are used in number conversion codes. Which of the following statements is correct?

    1) The alphabetic characters indicate which card columns are used and the numeric characters indicate the desired mode of the number.
    2) The alphabetic characters indicate the desired mode of the number and the numeric characters indicate which card columns are used.
    3) The alphabetic and numeric characters are used jointly to indicate the desired mode of the number.
    4) The alphabetic characters are only variable names; the numeric characters tell the desired mode of the number and which card columns are used.

23. Which of the following may be used as subscripts to the variables in the READ statement list?

    1) constants
    2) variables
    3) limited expressions
    4) all of the above

24. The statement FORMAT(F12.4,F10.5,F6.2) denotes how many numbers per card?

    1) 12
    2) 10
    3) 6
    4) 3

25. If the end of the FORMAT statement is encountered before the INPUT list is satisfied, what will happen?

1) the reading would discontinue and control will pass to the next statement in the program
2) the reading will continue repeating the specifications at the last open parentheses in the FORMAT statement
3) the reading will continue repeating the entire FORMAT statement completely
4) none of the above will occur

26. In IBM 360 FORTRAN, a variable name has:

1) only a single character
2) either one or two characters, but never more
3) five characters or less, but never more
4) six characters or less, but never more

27. Consider the following program segment:

```
DO 100 I = 1, N
K = N-1
DO 100 J = 1,K
```

If N = 20 what is the value of the upper index limit of the inner loop after the fourth time control has passed through the outer DO-loop?

1) 20
2) 4
3) 16
4) 1

28. If a READ statement request 100 values to be read and the FORMAT statement specifies four values on one card which of the following will happen?

1) Execution of the READ statement will cause only four values to be read.
2) Execution of the READ statement will cause four cards to be read.
3) Execution of the READ statement will cause 100 cards to be read.
4) Execution of the READ statement will cause 25 cards to be read.

29. Which of the following FORTRAN expressions correctly performs the arithmetic indicated in the formula v^{3k+m} ?

1) `V*3K+M`
2) `V*3*K+M`
3) `V**(3*K+M)`
4) `V**3**(K+M)`

30. With the combination of statements READ(1,1)A,B and 1 FORMAT (6F12.4) how many <u>columns</u> will be read on the card?

1) 6
2) 24
3) 72
4) 12

31. The statement 5 FORMAT(F10.1) will specify how many decimal places?

1) 2.7
2) 3.7
3) 3
4) 4

32. According to the text which of the following devices can the IBM 360 computer use to "read" information.

1) punched cards
2) paper tape
3) magnetic tape
4) all of the above

33. After execution of a statement K=X+1.0 the value of K would be which of the following when X was 2.7?

1) 2.7
2) 3.7
3) 3
4) 4

34. Which of the following quantities may be contained in a READ statement list?

1) non-subscripted variables
2) variables with constant subscripts
3) self-indexed sequences with dummy subscripts
4) all of the above

35. Which of the following statements describes what will be read from a third card using the FORMAT (I6/(6F12.5))?

1) one fixed-point number
2) six floating-point numbers
3) one fixed-point number and six floating-point numbers
4) one floating-point number

36. Which one of the following best describes what the computer would do with the statement 1 FORMAT(F12.6) and the statement READ(1,1)X?

1) the computer would convert the contents of the first 12 columns of a card into a fixed-point number

2) the computer would convert the contents of the first 6 columns of a card into a floating-point number
3) the computer would convert the contents of the first 12 columns of a card into a floating-point number
4) the computer would convert the contents of the first 6 columns of a card into a fixed-point number

37. Which of the following statements best specifies the symbols which may be used to represent quantities in arithmetic formula statements?

1) Both alphabetic and numeric symbols may be used.
2) Only alphabetic symbols may be used.
3) Only numeric symbols may be used.
4) Either alphabetic or numeric cymbols may be used, but not both.

38. To alter the normal order of execution of FORTRAN statements, the programmer can use:

1) arithmetic formula statements
2) input-output statements
3) control statements
4) all of the above

39. After executing the statement IF(A+B)10,15,20 the computed value of A+B is:

1) not available if needed in future statements
2) available for use in future statements
3) is sometimes available for future statements depending upon the specific circumstances
4) is not available for future statements and cannot be recomputed

40. The statement which supplies the computer with information about the expected layout of data on cards is the:

1) READ statement
2) WRITE statement
3) FORMAT statement
4) arithmetic formula statement

41. The statement READ(1,2) (X(K),K=1, 1000) will cause how many numbers to be read?

1) 1
2) 1000
3) K
4) 2

42. Which of the following statements is most correct?

1) Decimal points should never be punched in floating-point numbers read from cards
2) Decimal points must be punched in floating-point numbers read from cards
3) Decimal points do not have to be punched in floating-point numbers read from cards but punching them is advisable
4) Usually decimal points should not be punched in floating-point numbers but occasionally they must be

43. Given the statement READ (1,2) (A(I),I=1,100) the sixth number read by the statement would be assigned to:

1) A(3)
2) B(3)
3) A(6)
4) B(6)

44. The value of 5 factorial (5!) is:

1) 5
2) 25
3) 120
4) 125

45. In which of the following, must the conversion codes listed have a corresponding variable in an OUTPUT list (assuming they are used in a FORMAT statement associated with a WRITE statement)?

1) F, I and H
2) F and I
3) H
4) I and H

46. In the statement DO 50 I=1,99,2 the loop is terminated when the index reaches the value of:

1) 99
2) 98
3) 100
4) the loop is terminated when the statement is first encountered because it is illegal

47. The execution of READ(1,1)N and 1 FORMAT(F8.4) will

1) convert the mode in the same way as the statement N = X
2) cause a floating-point number to be assigned to the N unlike the statement N = X,
3) work like the arithmetic formula statement X = N converting the mode correctly.
4) cause a fixed-point number to be assigned to the variable N like in X = N.

48. Consider the example WRITE(1,1) (A(1),I = 1,100) 1 FORMAT (8H A ARRAY// (10F12.4)). Without the set of parentheses around 10F12.4 which of the following would happen?

1) the computer would print in alternating fashion A ARRAY then 10 numbers, A ARRAY then 10 numbers, etc.
2) the computer would print A ARRAY then 10 numbers, 10 numbers, 10 numbers, etc.
3) the computer would print A ARRAY 10 numbers and stop
4) none of the above would happen

49. A decimal point in a constant:

1) is always illegal
2) identifies it as a fixed-point number
3) identifies it as a floating-point number
4) is permissable in either fixed-point numbers or floating-point

50. The reason why the values of variables are sometimes set equal to a constant with an arithmetic formula statement is to:

1) permit the definition of an initial value of the variables
2) assure the programmer of the value to which the variable is equal
3) provide a dummy value which is not used by the computer
4) 1 and 2 above are correct but not 3.

51. After the computer executes the statement J = 2.99999, the value of J will be:

1) 2.99999
2) 0
3) 2
4) 3

52. Consider the statement combination WRITE(3,1) (A(I),I = 1,1000) and 1 FORMAT (10F12.4). The first printed line in this example will contain the values from positions 1 to:

1) 10 of the A array
2) 1000 of the A array
3) 12 of the A array
4) 100 of the A array

53. Consider the following program segment:

```
K=X+1.0
GO TO (8,9,13,17),K
```

If X equals 1.987, control will pass to the statement having which of the following statement numbers after executing the computed GO TO?

1) 8
2) 9
3) 13
4) 17

54. The statement FORMAT(5F2 0.5/6F20.6) will specify:

1) five numbers on the first line; six on the second and five on the third
2) five numbers on the first line, six on the second and third lines
3) five numbers on the first 20 lines, six on the second 20 lines
4) twenty numbers on the first five lines and 20 on the next 6 lines

55. Which, if any, of the following statements best describes the arithmetic formula statement I = I + 1?

1) this statement is illegal and cannot be executed by the computer
2) this statement is legal and causes the quantity 1 to be added to the previous value of I to form a new value for I
3) because I is on both sides of the equal sign, this statement causes a loop which is non-ending
4) none of the above statements are correct

56. When two DO-loops are nested, which one of the following situations occurs?

1) The outer loop is begun first. During its first pass the inner loop cycles completely
2) The outer loop cycles completely first, then the inner loop cycles completely
3) The inner loop is begun first and cycles completely before passing control to the outer loop
4) The inner loop begins first and o. its first pass gives control to the outer loop which completely cycles itself

57. Which of the following conversion codes is used to write alphabetic information?

1) X
2) H
3) I
4) F

58. To use the FORTRAN shorthand version of representing decimal numbers, the number 0.000007 might be represented as:

1) 7.E6
2) 7.E-6
3) 7.E-7
4) 7.E+7

59. What is the carriage control character in the statement FORMAT (10X,6HANSWER)?

1) 1
2) X
3) blank
4) 6

60. Computers make decisions in executing control statements. The basic decision in control statements the computer makes is:

1) which statement is to be executed next?
2) what values are to be substituted for the variables in this expression?
3) which arithmetic operation is to be performed next?
4) all of the above are basic decisions made in executing control statements

61. If a card containing only the number 1 punched in column 1 were read by the sequence READ(1,1)I,J,K and 1 FORMAT(3I5), the value of the variable I would become:

1) 1
2) 100
3) 10000
4) none of the above

62. The quantity in the index definition in a DO loop which specifies the size of step by which the index count is advanced each time is the:

1) first quantity to the right of the equal sign
2) second quantity to the right of the equal sign
3) the third quantity to the right of the equal sign
4) the fourth quantity to the right of the equal sign

63. Which of the following expressions, if any, does not illustrate a floating-point exponent?

1) X**0.37
2) Y**I
3) X**1.73
4) all of the above expressions illustrate a floating-point exponent

64. The use of the subscripted variable X(I):

1) will refer to the ith number in the list depending on the value of the variable I
2) will refer successively to the first number in the list, the second number, the third number and so on.
3) is an illegal form because I is not a constant number in the list
4) by previous definition refers to the 25th number in the list

Booklet Number 15

PSYCHOLOGICAL ACHIEVEMENT TEST

FORM B

- Do not write on this test booklet -

- Write only on the answer sheet provided -

INSTRUCTIONS:

1. This is a multiple choice test in psychology. There is no time limit for this test. Most students will finish in 45 to 60 minutes.
2. Complete the information requested on the answer sheet.
3. Record your answers by filling in the corresponding space on the answer sheet. You may use any pencil.
4. If you have any questions about how to take this examination, ask the monitor.

- DO NOT WRITE ON THIS TEST BOOKLET -

Prepared by Dr. J. M. Flynn, Nova University, 1968

1. During an air attack the odor of a bomb shelter may be paired with the stimuli which elicits fear during the attack. If so, this will be an example of

    1) arranged operant conditioning.
    2) arranged respondent conditioning.
    3) accidental operant conditioning.
    4) accidental respondent conditioning.

2. Head scratching, pencil chewing and table tapping by a student while he is solving a problem are most likely to be a form of

    1) unconditioned problem solving behavior.
    2) superstitious problem solving behavior.
    3) generalized problem solving behavior.
    4) adaptive problem solving behavior.

3. A thirsty man who sees a drinking fountain will probably go to the fountain because

    1) walking to the fountain has been reinforced in the past when he was thirsty.
    2) walking to the fountain is an unconditioned response.
    3) the fountain is an unconditioned stimulus.
    4) 1 and 3 are correct, but not 2.

4. A green key is an S^{Δ} for key pecking by a pigeon, and a red key is an S^{D} in a fixed ratio schedule of 25 responses. After the key turns green,

    1) no responses are reinforced.
    2) all responses are reinforced.
    3) the twenty-fifth response is reinforced.
    4) the twenty-sixth response is reinforced.

5. In a typical operant conditioning experiment, the experimenter arranges a mechanical or electrical device to

    1) reinforce any response.
    2) reinforce a specific response.
    3) reinforce occasional responses regardless of their nature.
    4) reinforce any frequently occurring response.

6. In the usual operant experiment, bending down to the magazine makes the food visible and the pigeon seizes the food with its beak. Which of the following statements most correctly describes the situation?

    1) With respect to seizing food, the sight of food is a S^{Δ}.
    2) With respect to bending down, the sight of food is a reinforcer.
    3) With respect to seizing food, the sight of food is a S^{D}.
    4) Statements 2. and 3. above are correct, but not statement 1.

7. The highest rate of responding is generated by which of the following schedules of reinforcement

   1) variable-ratio
   2) fixed-interval
   3) variable-interval
   4) fixed-ratio

8. A chimpanzee drops coins into a vending machine which delivers peanuts. The peanuts are

   1) conditioned reinforcers
   2) secondary reinforcers
   3) unconditioned reinforcers
   4) accidental reinforcers

9. If a drill instructor says "right face!" and all of his men turn to the right, it can be said that their behavior

   1) is a conditioned response under the control of a verbal stimulus.
   2) is an unconditioned response under the control of a verbal stimulus.
   3) has been reinforced on a fixed-ratio schedule.
   4) demonstrates complete stimulus generalization to verbal stimuli.

10. A particular schedule of reinforcement always has 325 responses between reinforcements. This schedule is called a

   1) variable-interval chain.
   2) continuous schedule.
   3) fixed-interval schedule
   4) fixed-ratio schedule

11. The procedure with which a trainer teaches a dog to jump through a hoop is called

   1) response differentiation
   2) response extinction
   3) superstitious behavior
   4) adaptative behavior

12. Smooth muscle fibers are found in which of the following:

   1) the arms
   2) the stomach
   3) the neck
   4) all of the above

13. In the standard experimental box the click of the food magazine is an effective reinforcer for pecking because

1) the click occurs instantly but there is a short delay before reinforcement with food.
2) food occurs instantly but there is a short delay before reinforcement with the click.
3) reinforcement by the click and by the food both occur instantly.
4) reinforcement with the click and the food are both delayed.

14. The technique of reinforcing a response in the presence of one stimulus and not reinforcing it in the presence of another stimulus is used to establish

1) an adaptation
2) a superstition
3) a discrimination
4) a generalized reinforcer

15. The term which best describes the stiuation in which some responses are reinforced while some rather similar responses are not reinforced is

1) adaptive reinforcement
2) differential reinforcement
3) accidental reinforcement
4) generalized reinforcement

16. A child has a temper tantrum and screams for candy. The mother gives the candy to the child and the tantrum ceases. Which one of the following statements best describes this situation?

1) Termination of the tantrum negatively reinforces the mother's response of handing candy to the child.
2) The termination of the tantrum positively reinforces the mother's response of handing candy to the child.
3) Handing candy to the child negatively reinforces the tantrum.
4) The mother's response of handing candy to the child is not reinforced.

17. If only red apples are always sweet and edible and green apples are never sweet and edible, which of the following statements is correct for the response of picking and eating an apple?

1) The "redness" or "greenness" of an apple is an S^D.
2) The "redness" or "greenness" of an apple is an S^Δ.
3) The "redness" of an apple is an S^Δ and the "greenness" of an apple is an S^D.
4) The "redness" of an apple is an S^D and the "greenness" of an apple is an S^Δ.

18. Vomiting due to chemical irritants in the stomach is:

1) a conditioned response.
2) an unconditioned response.
3) a conditioned stimulus.
4) an unconditioned stimulus.

19. In a chain of behavior, the presence of food

1) can be a discriminative stimulus, but not a reinforcing stimulus.
2) can be a reinforcing stimulus, but not a discriminative stimulus.
3) can be both a discriminative and reinforcing stimulus.
4) can be neither a discriminative nor reinforcing stimulus.

20. Which of the following statements is true of continuous reinforcement:

1) Every response is reinforced and the time required for extinction is long.
2) Many, but not all, of the responses are reinforced and the time required for extinction is short.
3) Every response is reinforced and the time required for extinction is short.
4) Many, but not all, of the responses are reinforced and the time required for extinction is long.

21. In a typical operant conditioning experiment, a pigeon might be placed in a box which has a key for pecking and a food magazine. To condition operant behavior the apparatus

1) pairs a conditioned stimulus with the presentation of food in the magazine.
2) reinforces any response which occurs by presenting the animal with food.
3) elicits specific responses by presentation of food.
4) reinforces specific responses when they are emitted.

22. Even though reinforcement can only occur after a response, the shortest interval in a variable-interval schedule

1) may not be any smaller than the average interval.
2) may be so small that one reinforcement occurs immediately after another reinforcement.
3) must be at least one minute in length.
4) is the same length as the longest interval because all of the intervals are the same length.

23. A pigeon's key pecking response is not followed by reinforcement. Which of the following statements, if any, best describes the future occurrence of key pecking responses.

1) They will probably occur less frequently in the future than if the response had been followed by reinforcement.
2) They will probably occur more frequently in the future than if the response had been followed by reinforcement.
3) They will probably occur as frequently in the future as if the response had been followed by reinforcement.
4) None of the above statements describe the future occurrence.

Read the following before answering questions 24 and 25:

In a standard respondent conditioning experiment a tone was paired with a meat powder and the saliva flow of the dog was measured. There were 60 trials. On trials 1, 12, 24, 36, 48 and 60, the tone was presented alone (i.e., meat powder was not used). The table below shows the amount of saliva flow and the time between onset of tone and salivation on each of these test trials.

Trial No.	Drops of Saliva	Time Between Onset of Tone and Salivation (in seconds)
1	0	-
12	8	15
24	27	7
36	68	3
48	72	2
60	71	2

24. On Trial 12, the tone alone was presented and 8 drops of saliva flowed. This is evidence that the tone was already:

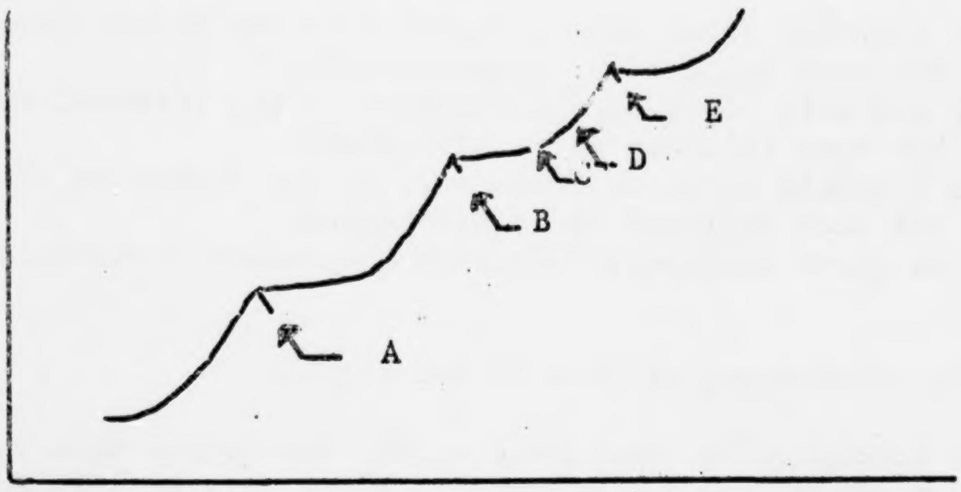
1) a conditioned response
2) a conditioned stimulus
3) an unconditioned response
4) an unconditioned stimulus

25. From this experiment, we can conclude that as the number of trials in which the conditioned and unconditioned stimuli are paired increases:

1) the latency of the conditioned reflex increases and the magnitude of the conditioned response increases until both reach a limit.
2) the latency of the conditioned reflex decreases and the magnitude of the conditioned response decreases until both reach a limit.
3) the latency of the conditioned reflex decreases and the magnitude of the conditioned response increases until both reach a limit.
4) the latency of the conditioned reflex increases and the magnitude of the conditioned response decreases until both reach a limit.

Read the following figure and use it for question 26 and 27

RECORD OF A PIGEON ON A FIXED INTERVAL SCHEDULE



26. The hatch marks at points A, B, and E in the figure most probably indicate that the pigeon's responses were

    1) extinguished at these points.
    2) reinforced at these points.
    3) absence at these points.
    4) not reinforced at these points.

27. At which of the following intervals in the above figure is the rate the lowest

    1) between C and D
    2) between D and E
    3) between B and C
    4) between A and B

28. If a cigarette lighter fails to light and the person stops trying to light it after a very few attempts, we can most probably assume that his previous lighting responses were reinforced on a

    1) continuous schedule
    2) variable-interval schedule
    3) variable-ratio schedule
    4) fixed-ratio schedule

29. If in teaching a student to throw a javelin the track coach is satisfied with every throw no matter how bad it may be, he is using which of the following techniques

    1) he is using successive approximation, but he is not using differential reinforcement.
    2) he is not using successive approximation but he is using differential reinforcement.
    3) he is using successive approximation and he is using differential reinforcement.
    4) he is not using successive approximation and he is not using differential reinforcement.

30. Which one if any of the following statements about reinforcement is correct?

1) Positive reinforcement increases the rate of response while negative reinforcement decreases the rate of response.
2) Both positive and negative reinforcement increase the rate of response.
3) Positive reinforcement decreases the rate of response and negative reinforcement increases the rate of response.
4) None of the above statements are correct.

31. When reinforcements are never close together in time, which of the following situations would most likely occur immediately after reinforcement?

1) Rapid responding.
2) A few responses followed by a long pause.
3) A single response followed by a long pause.
4) A pause in responding.

32. In shaping animal behavior such as that of a dog the first step is often to establish a sound such as a click as a reinforcer by repeatedly pairing it with food. One reason for using an auditory stimulus instead of food in training the dog is

1) the auditory stimulus is a primary reinforcer whereas the food is not.
2) the auditory stimulus affects the dog immediately whereas the food may not.
3) the auditory stimulus is a generalized reinforcer whereas the food is not.
4) the click can be used for continuous reinforcement whereas the food can only be used on a ratio schedule.

33. If we consistently get no answer when we dial a number on the telephone we stop dialing. This process is called

1) negative reinforcement
2) positive reinforcement
3) extinction
4) adaptation

34. When you telephone a friend who is frequently not at home, your reinforcement by getting an answer is most likely on

1) a ratio-schedule.
2) an interval-schedule.
3) a continuous reinforcement schedule.
4) no particular reinforcement schedule.

35. Which of the following methods will most likely be used to shape a complex skill?

1) generalized reinforcement of unconditioned responses
2) pairing of conditioned stimuli with unconditioned stimuli
3) differential reinforcement of successive approximations to the final behavior
4) continuous reinforcement of generalized behavior through the use of second dary reinforcers

36. Money is

1) an unconditioned reinforcer
2) a primary reinforcer
3) a generalized reinforcer
4) all of the above

37. A dog has been conditioned to salivate at the sound of a tuning fork. Later, the experimenter wants to extinguish the conditioned response. Which of the following methods would lead to extinction:

1) Repeated presentation of the tuning fork with food powder.
2) Repeated presentation of food powder without the tuning fork.
3) Repeated presentation of the tuning fork without meat powder.
4) Repeated presentation of meat powder occasionally paired with the tuning fork.

38. Which of the following statements is true for a multiple schedule?

1) Behavior in a multiple schedule can only be reinforced by primary reinforcers.
2) A multiple schedule can consist only of a fixed interval schedule alternating with a fixed ratio schedule.
3) In a multiple schedule, behavior comes under stimulus control.
4) Reinforcement in a multiple schedule can only be by conditioned reinforcers.

39. A response is said to have become more probable if under controlled conditions

1) it is observed to occur more frequently than it did at some previous time.
2) it is observed to occur less frequently than at some previous time.
3) its latency is observed to increase.
4) its magnitude is observed to increase.

40. One way in which to train a dog not to sit still is by withholding reinforcement until the dog moves. The term which best describes this technique is called

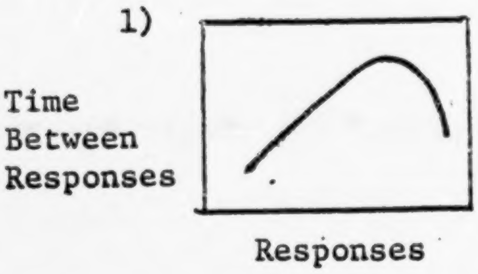
1) accidental reinforcement
2) primary reinforcement
3) continuous reinforcement
4) differential reinforcement

41. If a pigeon is placed in an experimental box for the first time, which of the following pecking response patterns is most likely to occur before the pigeon becomes accustomed to the situation?

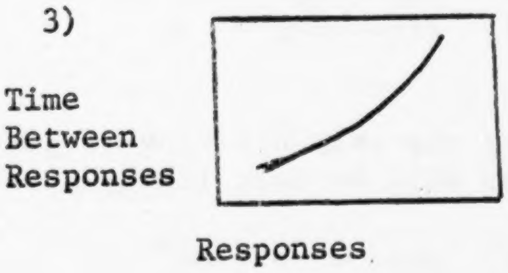
1) Relatively long pauses between responses.
2) Extremely short pauses between responses.
3) Alternating long and short pauses between responses.
4) None of the above.

42. If the time between pecking responses for a pigeon placed in an experimental box for the first time and under a schedule of continuous reinforcement were plotted, which of the following figures would most nearly resemble the resultant graph?

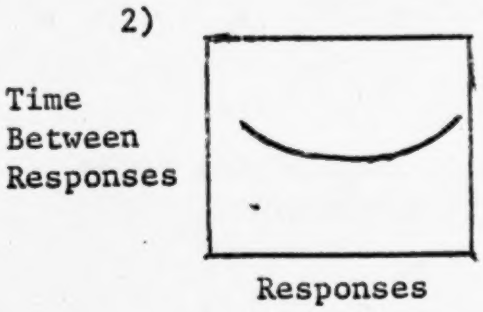
1)



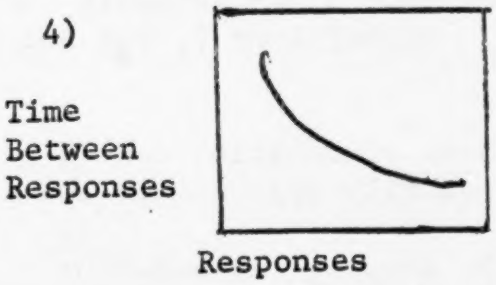
3)



2)

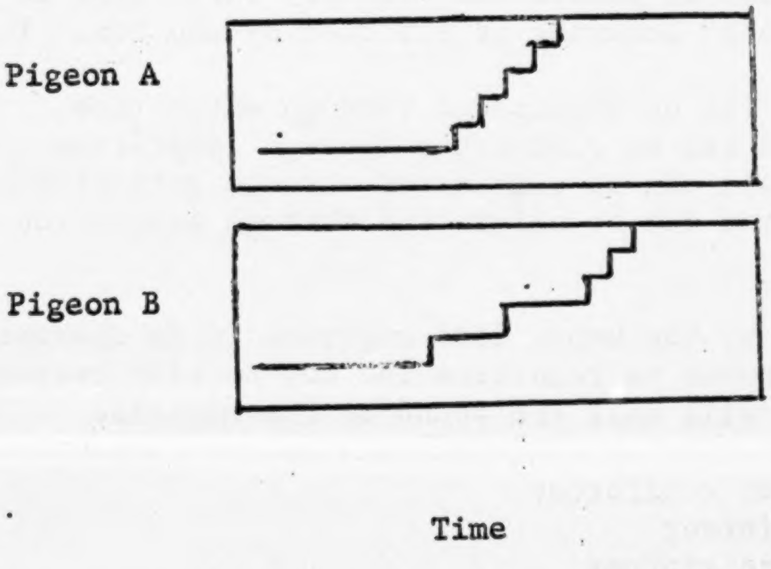


4)



Refer to the following figure for questions 43 and 44.

The figures shown are the cumulative records of conditioned key pecking by two pigeons. All responses were reinforced.



43. In Figure A, Pigeon A reached his maximal rate of responding after

1) 1 reinforcement
2) 4 reinforcements
3) 8 reinforcements
4) 11 reinforcements

44. In comparing records for Pigeon B with those for Pigeon A, which of the following statements is correct.

    1) The maximal rate of responding was significantly faster for A than for B.
    2) The maximal rate of responding was significantly slower for o than for B.
    3) A longer time elapsed between the first, second and third responses for B than for A.
    4) The responses for both pigeons occurred at the same frequency.

45. Which of the following are a direct result of actions of the glands:

    1) chewing
    2) sweating
    3) blushing
    4) breathing

46. A bowler may snap his fingers just as the ball hits the pins. His finger snapping behavior will be most likely reinforced if he

    1) gets a "strike"
    2) picks up a spare
    3) gets a 7 - 10 split
    4) Either 1 or 2, but not 3

47. "New" forms of behavior can be generated by differentially reinforcing forms which gradually approximate the final form. We call this procedure

    1) shaping the behavior
    2) generalizing the behavior
    3) adapting the behavior
    4) emitting the behavior

48. When a food deprived pigeon is placed for the very first time in a standard experimental box "emotional" behavior is elicited by the box. This behavior is

    1) conditioned and can be eliminated through extinction.
    2) conditioned and can be eliminated through adaptation.
    3) unconditioned and can be eliminated through extinction.
    4) unconditioned and can be eliminated through adaptation.

49. Sometimes the click made by the empty food magazine in an operant conditioning experiment acquires the power to reinforce the key pecking response of the pigeon. In this case we will call the sound of the magazine

    1) an unconditioned reinforcer
    2) a primary reinforcer
    3) a conditioned reinforcer
    4) a generalized reinforcer

50. Stimuli which were never present at reinforcement

1) will never acquire control over the response.
2) may acquire control over the response through accidental reinforcement.
3) frequently acquire control over the response although practically nothing is known about the conditions under which they acquire this control.
4) may acquire control over the response if a similar stimulus has been present during reinforcement.

51. One way in which to extinguish behavior you do not want another person to emit is by

1) showing them affection when they emit the behavior
2) withholding approval when they do not emit the behavior
3) using a generalized reinforcer when they emit the behavior
4) withholding approval when they emit the behavior

52. A worker in an electronics factory is paid $3 for every lot of 15 tuning knobs which his machine produces. Since he is reinforced only when he finishes a lot the reinforcement is on

1) a variable-ratio schedule
2) a fixed-interval schedule
3) a continuous-reinforcement schedule
4) a fixed-ratio schedule

53. When reinforcement is discontinued after a response has been maintained on a variable interval schedule, responses

1) are emitted at a gradually declining rate for a long period of time.
2) are emitted at a rapidly declining rate for only a short period of time.
3) are emitted at a constantly high rate for an indefinite period of time.
4) will cease to be emitted almost immediately.

54. Which of the following techniques will effectively prevent unwanted conditioned behavior?

1) Condition some incompatible behavior.
2) Withhold reinforcement occasionally when the behavior is emitted.
3) Withhold reinforcement every time the behavior is emitted.
4) Both 1 and 3 will effectively prevent the behavior but not 2.

55. Frequently words like "bad" and "wrong" elicit emotional responses in a person. These responses are:

1) unconditioned responses (i.e., not learned by the person).
2) conditioned responses (i.e., learned by the person).
3) sometimes unconditioned responses and other times conditioned responses.
4) inherited by the person through the genes.

56. A reinforcement schedule which provides reinforcements after a set number of responses is called

1) a variable-ratio schedule
2) a fixed-ratio schedule
3) a variable-interval schedule
4) a fixed-interval schedule

57. Which of the following is a synonym for "unconditioned reinforcer"?

1) secondary reinforcer
2) primary reinforcer
3) conditioned reinforcer
4) accidental reinforcer

58. When a child uses the word "dog" only in response to dogs, which of the following processes has taken place?

1) Adaptation
2) Generalization
3) Discrimination
4) Elicitation

59. If a conditioned reinforcer is paired with several different unconditioned reinforcers, it becomes

1) an accidental reinforcer
2) an unconditioned reinforcer
3) a generalized reinforcer
4) a primary reinforcer

60. Which of the following statements is the best psychological interpretation of the question "what does he see in her?"

1) "How does he reinforce her courting behavior?"
2) "How does she reinforce his courting behavior?"
3) "How does she extinguish his courting behavior?"
4) "How does he extinguish her courting behavior?"

61. When a student is studying he may persistently scratch his head and chew on his pencil. Frequently these behaviors are conditioned superstitious operants resulting from

1) differential reinforcements of successive approximations to a final behavior.
2) the pairing of unconditioned stimuli with conditioned stimuli.
3) accidental contingencies of reinforcement.
4) continuous reinforcements of high probability behavior.

62. If the child who first calls all books "green" is not reinforced for saying "green" to books of other colors, he will soon call only green books "green". Thus, books of other colors

1) come to provide S^D's for the response of saying "green".
2) become S^Δ for the response of saying other colors.
3) come to provide S^Δ's for the response of saying "green".
4) become unconditioned S^D for eliciting the response of saying "green".

63. Which of the various schedules of reinforcement do the following statements describe: There is a pause after reinforcement. Responding then resumes and is positively accelerated until it reaches a terminal steady rate before next reinforcement.

1) fixed-interval
2) variable-ratio
3) variable-interval
4) fixed-ratio

64. A pigeon has been given food each time it pecks a disk. Later when food no longer follows pecking, the rate in emitting the response is observed to decline gradually. The term which best describes this process is

1) S^D
2) extinction
3) differential reinforcement
4) adaptation negative reinforcement

02

Booklet Number ________________

STATISTICS ACHIEVEMENT TEST

FORM A

- Do not write on this test booklet -

- Write only on the answer sheet provided -

INSTRUCTIONS:

1. This is a multiple choice test in statistics. There is no time limit for this test. Most students will finish in 45 to 60 minutes.
2. Complete the information requested on the answer sheet.
3. Record your answers by filling in the corresponding space on the answer sheet. You may use any pencil.
4. If you have any questions about how to take this examination, ask the monitor.

-DO NOT WRITE ON THIS TEST BOOKLET -

Prepared by Dr. J. M. Flynn, Nova University, 1968

1. The first step in transforming raw scores into Z scores is:

   1) adding 50 to the score
   2) multiply the score by 10
   3) convert the raw scores to the z scores
   4) subtract the standard deviation from the score

2. Which of the following formulas is most convenient for computing the standard deviation from raw data?

   1) $S = \frac{1}{N}\sqrt{N\Sigma X^2-(\Sigma X)^2}$

   2) $S = \sqrt{\frac{\Sigma(X-\bar{X})^2}{N}}$

   3) $S \quad \sqrt{\frac{N\Sigma X^2-(\Sigma X)^2}{N^2}}$

   4) $S = \sqrt{\frac{\Sigma X^2}{N}}$

3. If the mean of a frequency distribution is 37.2 and the standard deviation is 5.3, a score value of 42.5 is:

   1) one standard deviation below the mean
   2) 79.7 standard deviations above the mean
   3) 5.3 standard deviations above the mean
   4) one standard deviation above the mean

4. The mean for a set of scores is three. If three is subtracted from each score, what effect will this have on the mean?

   1) the mean will become 6
   2) the mean will remain 3
   3) the mean will become zero
   4) the mean will become 9

5. When points on a plane are located by noting their distance from two intersecting perpendicular lines on a plane, this is the:

   1) triangular coordinate system
   2) quadrangular coordinate system
   3) polar coordinate system
   4) rectangular coordinate system

6. If measurements are being reported to the nearest 1/2 inch, the real limits of the measure 48" are:

   1) 47" and 49"
   2) 47-1/2" and 48-1/2"
   3) 47-3/4" and 48-1/4"
   4) none of the above

7. A sample which has a lot of variation in some attribute is said to be:

1) homogeneous
2) variable
3) heterogeneous
4) dispersed

8. If a constant is subtracted from each score in a distribution which of the following statements is correct?

1) both the mean and the variance are affected
2) neither the mean nor the variance are affected
3) the variance but not the mean is affected
4) the mean, but not the variance is affected

9. If, in a frequency distribution of IQ scores, a score of 119 has a cumulative frequency of 25, it means:

1) 25 people made an IQ score of 119
2) 25 people made IQ scores of less than 119
3) 25 people made IQ scores of 119 or less
4) none of the above

10. Which of the following are also percentiles?

1) the median
2) the upper quartile
3) the lower quartile
4) all of the above are percentiles

11. If the cumulative frequency of a score of 101 in a class of 50 students is 7, what is the percent of the class that has an IQ of 101 or less?

1) 14%
2) 7%
3) 35%
4) the percent cannot be determined without further information

12. Which of the following statements is correct.

1) If a variable is continuous it must be unordered.
2) If a variable is continuous it can be either ordered or unordered.
3) If a variable is continuous it must be ordered.
4) If a variable is continuous there is no sense talking about whether it is ordered or unordered.

13. Which measure of central tendency most strongly reflects the influence of very high or very low scores?

1) the mean
2) the mode
3) the median
4) the interquartile range

14. In a histogram which of the following, if any, represents the frequency of the scores for a class interval?

1) the height of the rectangle for the corresponding class interval
2) the width of the rectangle for the corresponding class interval
3) the area of the rectangle for the corresponding class interval
4) none of the above

15. If the following seven scores make up a distribution, what is the median - 99, 101, 104, 105, 111, 118.

1) 101
2) 104
3) 105
4) 111

16. Which one of the following formulas is the formula for the z scores of a normal curve?

1) $Z = \frac{X-\mu}{\sigma}$

2) $Z = \frac{X-\overline{X}}{S}$

3) $Z = \frac{X-\mu}{\sigma}$

4) $X = \frac{X-\overline{X}}{\sigma}$

17. If an interval has real limits of 29.5 and 39.5, the class midpoint is

1) 34
2) 35
3) 34.5
4) 35.5

18. Which one of the following methods is the best way to eliminate negative scores in a distribution?

1) multiply every score by minus one
2) multiply each of the scores by a relatively large number
3) drop the minus signs of the negative scores
4) add a constant to every score which is larger than the greatest minus score

19. Midville College admits students who score in the upper third of the entrance examination, but not those who score in the lower two-thirds. Robert made a score at P79 of the entrance exam.

1) Robert was not admitted to Midville College
2) More information was needed to determine if Robert was admitted to Midville College or not
3) Robert was admitted to Midville Colleg
4) none of the above are correct

20. What does ΣX mean?

1) the product of the scores
2) the sum of all the score
3) to tell the number of scores
4) none of the above

21. Normally if we report the length of a house to be 44 feet, we mean that the house is

1) exactly 44 feet long
2) 44 feet more or less
3) at least 44 feet - it may be longer, but not less
4) a maximum of 44 feet - it may be less, but not longer

22. The score in a distribution attained by 50% of the group is called the:

1) range
2) mode
3) median
4) percentile rank

23. Which of the following statements is true about the normal curve?

1) The mean and mode are located at the same value but not the median.
2) The mode and median are located at the same value but not the mean.
3) The median and mean are located at the same value but not the mode.
4) The mean, median and mode are all located at the same value.

24. Which one of the following numbers represents the rule of thumb to determine how many groups to use in grouping data?

1) 5
2) 12
3) 20
4) 28

25. Look at the distribution of scores 3, 9, 14, 22, 31, 33, 60. What score is the median?

1) 14
2) 22
3) 18
4) 32

26. A point below the X-axis and to the left of the Y-axis will have:

1) two positive coordinates
2) two negative coordinates
3) a positive X coordinate, a negative Y coordinate
4) a positive Y coordinate, a negative X coordinate

27. In which of the following cases would an open-ended interval most likely be used?

1) when a few cases are far above or far below a great majority of the cases
2) when all the cases are pretty close together
3) when the cases group into clusters at the opposite ends of the distribution
4) in all the above cases

28. If you folded a normal curve at the median, the area under the curve to the left and the right of the line would:

1) usually be equal, but not always
2) never be equal
3) always be equal
4) sometimes be equal but not very often

29. The mean of a distribution of z scores is equal to:

1) 0
2) 1
3) the original mean of the scores
4) it depends upon the particular distribution

30. In a distribution the score achieved by the most people is called the
1) median
2) mode
3) range
4) mean

31. Which of the following numbers are the real limits for an IQ score of 76?

1) 75 and 77
2) 75.5 and 76.5
3) 75.75 and 76.25
4) 75.99 and 76.11

32. Which of the following measures is calculated from the deviations of each score from the mean of the distribution?

1) the variance
2) the interquartile range
3) the median
4) the range

33. Quartiles divide a distribution into:

1) halves
2) tenths
3) one-hundreths
4) quarters

34. If X = 40 and z = 8, what does X equal when z equals 2?

1) 56
2) 34
3) 48
4) 24

35. Which one of the following variables is not an ordered variable?

1) scores on an IQ test
2) attitude toward the Little League
3) number of brothers and sisters
4) make of automobile

36. If $\mu = 55$ and $\sigma = 8$, then if $x = 69$, $z =$:

1) 1.75
2) 9.83
3) -.25
4) 32.69

37. If you tell a service man that your car is stalled 4 blockes South and 2 blocks West of the village square, you are locating your car by:

1) the polar coordinate system
2) the rectangular coordinate system
3) the triangular coordinate system
4) the quadrangular coordinate system

38. In order to determine an individual's average performance on several tests in different subjects, you should average his:

1) z scores
2) raw scores
3) percentile scores
4) none of the above

39. In order to find the mean of a distribution you would:

1) select the score with the greatest frequency
2) sum the scores and divide the N
3) find the score which divides the distribution in half
4) subtract the lowest score from the highest score

40. Which of the following operations transforms the scores in a distribution?

1) addition of a constant
2) subtraction of a constant
3) multiplication by a constant
4) all of the above

41. The graph that depicts a grouped frequency distribution using rectangles for the frequency in each interval is called:

1) histogram
2) ogive
3) frequency polygon
4) none of the above

42. If John Doe's score on the history test has a z score of -1.03 it means that:

1) his original score was above the mean score of the class
2) his original score was below the mean score of the class
3) his original score was equal to the mean score of the class
4) no conclusions can be made about the relation of his score to the mean score of the class

43. During the interval from 1955 to 1967 Joe Smith earned salaries in excess of $10,000. every year. If in 1968 he earned no salary at all, which of the following statements would be most correct?

1) His mean annual salary and his median income would both decrease from the previous period.
2) His median income would increase but his mean annual salary would increase.
3) His median income would increase but his mean annual salary would decrease.
4) His mean annual salary and his median income would both increase.

44. A point lies on the X-axis and is three units to the left of the Y-axis. Its coordinates are:

1) (- 3,0)
2) (3,0)
3) (0,3)
4) (0,-3)

45. What is the midpoint of the interval having the score limits of 90 and 99?

1) 95
2) 95.5
3) 94.5
4) None of the above

46. What is the name of the value which divides a distribution into two equal parts? .

1) range
2) mode
3) median
4) mean

47. In grouped data a class interval of 109 to 100 occurs. The upper score limit for the interval is:

1) 109.5
2) 99.5
3) 100
4) 109

48. Which one of the following formulas represents the average of the squared deviations of scores from their mean?

1) $\frac{\Sigma(x - \bar{x})^2}{N}$

2) $\frac{\Sigma x - \bar{x}^2}{N}$

3) $\frac{(\Sigma x - \Sigma \bar{x})^2}{N}$

4) $\Sigma \bar{x} - \frac{\Sigma x^2}{N}$

49. Which of the following numbers best represents the area in the unit normal curve between the mean ordinate and the ordinate for $z = .50$?

1) .4998
2) .0000
3) .4332
4) .1915

50. What percent of the scores in a distribution lie below the first quartile?

1) 25%
2) 33%
3) 50%
4) 66%

51. Which of the following variables is not a continuous variable?

1) the amount of gasoline pumped into a car
2) the length of a desk
3) the number of dots on a pair of dice
4) a person's weight

52. If Q_1 equals 105.75 and Q_3 equals 122.71 in a distribution, then the interquartile range equals

1) 16.96
2) 105.75
3) 228.46
4) none of the above

53. If a reading score of 53 is 0.96 standard deviation below the mean, the standard score equivalent to that reading score is:

1) 0.96
2) -0.96
3) 53
4) none of the above

54. Which of the following measures is found by finding the difference between the highest and the lowest scores in a distribution?

1) the range
2) the median
3) the mode
4) the interquartile range

55. The range of a set of scores is 47. If these were placed into a grouped distribution, about how many score units should be included in each unit?

1) 3
2) 4
3) 6
4) 12

56. A score above P9 is better than at least

1) 10% of the scores in the distribution
2) 90% of the scores in the distribution
3) 9% of the scores in the distribution
4) all of the scores in the distribution

57. Which of the following variables, if any, is discrete rather than continuous?

1) the length of an automobile
2) the number of pairs of shoes sold by a salesman
3) the weight of a beefsteak
4) all of the above are continuous measures

58. If each unit of deviation from the arbitrary origin in a grouped distribution is equal to five score units, the mean deviation of 4.62 is equal to:

1) 4.62 score units
2) 5 score units
3) .92 score units
4) 23.10 score units

59. By which of the following methods could the number 4.2 not be obtained?

1) by measuring the length of a stick
2) by rolling a pair of dice
3) by measuring the amount of gasoline pumped into an automobile tank
4) by weighing a bag of fruit

60. If each score in a distribution is multiplied by a constant value of 10, the new mean is:

1) the same as the original
2) 10 times smaller than the original
3) 10 times larger than the original
4) 10 plus the original

61. Which of the following is the name of the graph of a cumulative frequency distribution?

1) histogram
2) ogive
3) frequency polygon
4) none of the above

62. For all normal curves the proportion of the area to the left of the ordinate -1σ is:

1) .3413
2) .5000
3) .1587
4) .9731

63. A score which indicates how many standard deviation units the raw score is from the mean is called a:

1) transformed score
2) standard score
3) percentile score
4) quartile score

TEST ANSWER SHEET

NAME ________________________ STUDENT # ____________ DATE ____________

Check test for which this answer sheet is being used:

_____ Astronomy _____ Computer Programming _______ Psychology _____ Statistics

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Fill in the space indicating the correct answer.

	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5		1	2	3	4	5
1.	☐	☐	☐	☐	☐	21.	☐	☐	☐	☐	☐	41.	☐	☐	☐	☐	☐	61.	☐	☐	☐	☐	☐
2.	☐	☐	☐	☐	☐	22.	☐	☐	☐	☐	☐	42.	☐	☐	☐	☐	☐	62.	☐	☐	☐	☐	☐
3.	☐	☐	☐	☐	☐	23.	☐	☐	☐	☐	☐	43.	☐	☐	☐	☐	☐	63.	☐	☐	☐	☐	☐
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5.	☐	☐	☐	☐	☐	25.	☐	☐	☐	☐	☐	45.	☐	☐	☐	☐	☐	65.	☐	☐	☐	☐	☐
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6.	☐	☐	☐	☐	☐	26.	☐	☐	☐	☐	☐	46.	☐	☐	☐	☐	☐	66.	☐	☐	☐	☐	☐
7.	☐	☐	☐	☐	☐	27.	☐	☐	☐	☐	☐	47.	☐	☐	☐	☐	☐	67	☐	☐	☐	☐	☐
8.	☐	☐	☐	☐	☐	28.	☐	☐	☐	☐	☐	48.	☐	☐	☐	☐	☐	68.	☐	☐	☐	☐	☐
9.	☐	☐	☐	☐	☐	29.	☐	☐	☐	☐	☐	49.	☐	☐	☐	☐	☐	69.	☐	☐	☐	☐	☐
10.	☐	☐	☐	☐	☐	30.	☐	☐	☐	☐	☐	50.	☐	☐	☐	☐	☐	70.	☐	☐	☐	☐	☐
	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5		1	2	3	4	5
11.	☐	☐	☐	☐	☐	31.	☐	☐	☐	☐	☐	51.	☐	☐	☐	☐	☐	71.	☐	☐	☐	☐	☐
12.	☐	☐	☐	☐	☐	32.	☐	☐	☐	☐	☐	52.	☐	☐	☐	☐	☐	72.	☐	☐	☐	☐	☐
13.	☐	☐	☐	☐	☐	33.	☐	☐	☐	☐	☐	53.	☐	☐	☐	☐	☐	73.	☐	☐	☐	☐	☐
14.	☐	☐	☐	☐	☐	34.	☐	☐	☐	☐	☐	54.	☐	☐	☐	☐	☐	74.	☐	☐	☐	☐	☐
15.	☐	☐	☐	☐	☐	35.	☐	☐	☐	☐	☐	55.	☐	☐	☐	☐	☐	75.	☐	☐	☐	☐	☐
	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5		1	2	3	4	5
16.	☐	☐	☐	☐	☐	36.	☐	☐	☐	☐	☐	56.	☐	☐	☐	☐	☐	76.	☐	☐	☐	☐	☐
17.	☐	☐	☐	☐	☐	37.	☐	☐	☐	☐	☐	57.	☐	☐	☐	☐	☐	77.	☐	☐	☐	☐	☐
18.	☐	☐	☐	☐	☐	38.	☐	☐	☐	☐	☐	58.	☐	☐	☐	☐	☐	78.	☐	☐	☐	☐	☐
19.	☐	☐	☐	☐	☐	39.	☐	☐	☐	☐	☐	59.	☐	☐	☐	☐	☐	79.	☐	☐	☐	☐	☐
20.	☐	☐	☐	☐	☐	40.	☐	☐	☐	☐	☐	60	☐	☐	☐	☐	☐	80.	☐	☐	☐	☐	☐

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Name __________________________

Student Number__________________

Date___________________________

Questionnaire on Astronomy

A. Read each statement carefully and mark it by circling the number which best indicates how much you agree or disagree with it according to the following scale:

1 Strongly agree

2 Tend to agree

3 Neither agree or disagree

4 Tend to disagree

5 Strongly disagree

(1)	I would like to read more about astronomy.	1 2 3 4 5
(2)	I would rather read a regular textbook on astronomy than have it taught by the materials I have just completed.	1 2 3 4 5
(3)	I did not like the way astronomy was taught in the materials I have just completed.	1 2 3 4 5
(4)	I would like to become an astronomer.	1 2 3 4 5
(5)	The booklets had a lot of mistakes in them.	1 2 3 4 5
(6)	The printing in the booklets was difficult to read	1 2 3 4 5
(7)	There was too much confusion in the classroom while I worked.	1 2 3 4 5
(8)	I learned a lot about astronomy from reading the materials.	1 2 3 4 5
(9)	I would like to see these booklets become part of the regular course work at Nova High School.	1 2 3 4 5

B. Additional comments about the project:

Name________________________

Student Number__________________

Date________________________

Questionnaire on Computer Programming

A. Read each statement carefully and mark it by circling the number which best indicates how much you agree or disagree with it according to the following scale:

1 Strongly agree

2 Tend to agree

3 Neither agree or disagree

4 Tend to disagree

5 Strongly disagree

(1) I would like to read more about computer programming. 1 2 3 4 5

(2) I would rather read a regular textbook on computer programming than have it taught by the materials I have just completed. 1 2 3 4 5

(3) I did not like the way computer programming was taught in the materials I have just completed. 1 2 3 4 5

(4) I would like to become a computer programmer. 1 2 3 4 5

(5) The booklets had a lot of mistakes in them. 1 2 3 4 5

(6) The printing in the booklets was difficult to read. 1 2 3 4 5

(7) There was too much confusion in the classroom while I worked. 1 2 3 4 5

(8) I learned a lot about computer programming from reading the materials. 1 2 3 4 5

(9) I would like to see these booklets become part of the regular course work at Nova High School. 1 2 3 4 5

B. Additional comments about the project:

Name______________________________

Student Number ____________________

Date______________________________

Questionnaire on Psychology

A. Read each statement carefully and mark it by circling the number which best indicates how much you agree or disagree with it according to the following scale:

1 Strongly agree

2 Tend to agree

3 Neither agree or disagree

4 Tend to disagree

5 Strongly disagree

(1) I would like to read more about psychology. 1 2 3 4 5

(2) I would rather read a regular textbook on psychology than have it taught by the materials I have just completed. 1 2 3 4 5

(3) I did not like the way psychology was taught in the materials I have just completed. 1 2 3 4 5

(4) I would like to become a psychologist. 1 2 3 4 5

(5) The booklets had a lot of mistakes in them. 1 2 3 4 5

(6) The printing in the booklets was difficult to read. 1 2 3 4 5

(7) There was too much confusion in the classroom while I worked. 1 2 3 4 5

(8) I learned a lot about psychology from reading the materials. 1 2 3 4 5

(9) I would like to see these booklets become part of the regular course work at Nova High School. 1 2 3 4 5

B. Additional comments about the project:

Name______________________________

Student Number____________________

Date______________________________

Questionnaire on Statistics

A. Read each statement carefully and mark it by circling the number which best indicates how much you agree or disagree with it according to the following scale:

1 Strongly agree

2 Tend to agree

3 Neither agree or disagree

4 Tend to disagree

5 Strongly disagree

(1) I would like to read more about statistics. 1 2 3 4 5

(2) I would rather read a regular textbook on statistics than have it taught by the materials I have just completed. 1 2 3 4 5

(3) I did not like the way statistics was taught in the materials I have just completed. 1 2 3 4 5

(4) I would like to become a statistician 1 2 3 4 5

(5) The booklets had a lot of mistakes in them. 1 2 3 4 5

(6) The printing in the booklets was difficult to read 1 2 3 4 5

(7) There was too much confusion in the classroom while I worked. 1 2 3 4 5

(8) I learned a lot about statistics from reading the materials. 1 2 3 4 5

(9) I would like to see these booklets become part of regular course work at Nova High School. 1 2 3 4 5

B. Additional comments about the project:

STUDENT RECORD SHEET

Complete a different STUDENT RECORD SHEET for each of the four sets of materials which you read (use the same sheet for both PARTS I and II of the same set).

Please Print:

NAME ____________________ / ____________________ / ______________
last / first / initial

STUDENT NUMBER ______________

Please Check the Appropriate Boxes for the Material Which You Are Now Reading:

BOOK:
☐ Astronomy
☐ FORTRAN
☐ Psychology
☐ Statistics

VERSION:
☐ 1
☐ 2
☐ 3
☐ 4

In the spaces provided below write in the date you begin reading each part of the material checked above. Then read the material and record all of your responses to the material on the attached RESPONSE RECORD SHEETS. After you finish each part of the material, record the date finished and the number of errors you made, if any, in the spaces provided below.

PART I: Date Began ________ ________ ________
month day year

Date Finished ________ ________ ________
month day year

Number of Errors ______________

PART II: Date Began ________ ________ ________
month day year

Date Finished ________ ________ ________
month day year

Number of Errors ______________

Please do not write in this space

gr ☐
no ☐☐☐☐
bk ☐
vn ☐

bg ☐☐☐☐☐
fn ☐☐☐☐☐
er ☐☐

bg ☐☐☐☐☐
fn ☐☐☐☐☐
er ☐☐☐

WHEN YOU HAVE FINISHED READING THE MATERIAL AND HAVE COMPLETED ALL PARTS OF THIS SHEET, RETURN IT TO THE MONITOR.

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NAME ______________________________

Check whether this sheet is being used for PART I or PART II:

____ PART I ____ PART II

RESPONSE RECORD SHEET

Record your responses in the spaces provided. Mark each incorrect responses with an "X" in the column headed "X." Do not use the same sheet for both PART I and PART II. Use additional sheets as needed.

RESPONSES	X	RESPONSES	X	RESPONSES	X

TOTAL NUMBER OF ERRORS THIS PAGE: ☐

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